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A
PRACTICAL METHOD
FOR FINDING THE
Longitude and Latitude of a Ship at Sea,
By Obſervations of the MOON;

~~533.g.~~ 14
2

With GENERAL RULES for computing the ſame,
Illuſtrated by EXAMPLES.

Together with all the neceſſary TABLES, and their Explanations.

To which are added,

TABLES of the Time the MOON paſſes the Meridian of
LONDON, and her Declination, for the Years 1763 and 1764.

With EXAMPLES of their Uſes in finding the Latitude and Variation.

By ROBERT WADDINGTON,
Teacher of the Mathematicks, in Three Tun Court, Miles's Lane, near the
Monument, LONDON.

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M DCC LXIII.

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1397 d 41

MVSEVM
BRITAN
NICVM

To the RIGHT HONOURABLE

GEORGE GRENVILLE, Eſq;

Firſt Lord of the Admiralty,

And the Reſt of the

Commiſſioners for the Longitude,

This TREATISE

Is humbly addreſſed

By their moſt Obedient

Humble Servant,

Three Tun Court,
Miles's Lane, Feb.
17, 1763.

Robert Waddington.

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INTRO-

INTRODUCTION.

AS the Method of determining the Longitude at Sea, by means of obſerving the Diſtance of the Sun and Moon, or the Moon and a known fixed Star or Stars (that is, by taking the Diſtance of the Moon from a Star on each Side) whereby many more Opportunities offer than Occaſions require for all the Purpoſes of Navigation; and this Method having been put in Practice by ſome ingenious Gentlemen in his Majeſty's Navy, as well as by the Rev. Mr. NEVIL MASKELYNE, F. R. S. and myſelf, in our Voyage to St. Helena (which we took by Order of the Gentlemen of the Royal Society) and by myſelf on Return from thence in the Oxford Indiaman, Capt. WEBBER; which Method of obſerving, as well as in computing, I conſiderably improved: in the firſt, by taking the Mean of ſeveral obſerved Diſtances (when Circumſtances would admit) for each Obſervation, as will appear by the following Examples; and in the ſecond Place by a Table I computed, in order to obtain the variable Quantity of the Moon's Motion by Interpolation, whereby I could readily get the true Longitude and Latitude of the Moon from the Pariſian Ephemeris, to any Day, Hour, and Minute required; by which means I was enabled to go through the whole Calculation of an Obſervation in about Three Quarters of an Hour. I frequently made Three or Four Obſervations after the Manner above-named, and computed them ſeparately; which being done, I took a Mean of them for the true Longitude of the Ship by Obſervation. The Reſults of the Longitudes by Obſervation, when made Land, differing ſo little from the Longitudes of thoſe Places, together with the continual Tendency and Agreement of the Longitudes reſulting from the Obſervations from time to time, as will appear by the following Account, which plainly ſhews its Uſefulneſs in practical Navigation. And for a further Confirmation of this Method, I made Obſervations (in like Manner) at St. Helena, and ſince my Return in London; and finding thoſe obſerved Longitudes to differ ſo little from the Longitudes computed from the beſt Aſtronomical Tables, I am fully ſatisfied this Method of determining the Longitude at Sea may always be depended upon to about a Degree, and generally to leſs than Half a Degree, or One Quarter thereof: therefore, ſince this Manner of finding the Longitude tends ſo greatly towards the Improvement of Navigation for the Safety of Ships, with many other Advantages, I cannot but earneſtly wiſh it may meet with the Encouragement due thereto.

Having found the ſame practicable and certain, and made it appear ſo to ſeveral of the Chief and Second Commanders of Ships in the Employ of the Honourable Eaſt India Company, and having had the Pleaſure of inſtructing ſome of thoſe Gentlemen in the Method to be uſed in obſerving and computing the ſame, I have, for the readier Execution of the ſaid Purpoſes, calculated ſome uſeful Tables, together with the Longitudes, Diameters, Hourly Motions, &c. of the Sun and Moon for January and February 1763; alſo the Latitude and Parallax of the Moon, with the Second Differences of the Longitude and Latitude of the Moon, for the more ready taking out from the Table thereof the variable Quantity of the Moon's Motion in Longitude and Latitude for the given Time, which I publiſh for the Uſe of the Seafaring Gentlemen by way of Specimen; whereby the Computation of an Obſervation may be more readily made; I have alſo made General Rules for the moſt proper Method of taking the Obſervations and for computing the ſame. And if Tables in like Manner were computed and publiſhed for Three Years before-hand (i. e. for Three Years to come) and from the beſt Aſtronomical Tables, with Mr. MAYER's corrected Equations applied, and the commanding Officers of Ships properly inſtructed, that after a few Years (I dare venture to ſay) no other or better Method of determining the Longitude at Sea would be deſired.

ROBERT WADDINGTON.

A
PRACTICAL METHOD
OF
Finding the LONGITUDE at SEA.

A TABLE of the Longitude, Latitude, Right Aſcenſion, and Declination of ſome of the fixed Stars that are proper to be obſerved, at the Limb of the Moon, in order to determine the Longitude of a Ship at Sea (or Place of Obſervation) adjuſted to the Firſt of January 1763, with their Annual Variations, for the more ready obtaining the true Longitude, Right Aſcenſion, and Declination (the Latitude being invariable) at any Time.

Names and Characters.	Mag.	Longitude.				+An. Va.	Latitude.		Right Aſc.			+An.Va.	Declination			An. Var.
		s	°	′	″	″	°	′	h.	′	″	″	°	′	″	″
α Aldebaran	1	2	6	28	39	50,34	5	29,0 S	4	24	20,8	3,4	16	0	52N	+ 8
α Caſtor	2	3	16	56	26	ditto	10	4,5N	7	19	26,4	3,9	32	23	8N	− 7
β Pollux	2	3	19	56	50	ditto	6	40,0N	7	30	47,2	3,7	28	34	46N	− 8
α Regulus	1	4	26	33	8	ditto	0	27,5N	9	59	43,6	3,3	13	7	9N	−17
α Virgin's Spike	1	6	20	32	12	ditto	2	2,1 S	13	12	31,4	3,1	9	54	58 S	+19
α South Balance	2	7	11	46	46	ditto	0	21,9N	14	37	50,0	3,3	15	2	30 S	+16
β North Balance	2	7	16	4	2	ditto	8	31,6N	15	4	19,2	3,2	8	29	30 S	+14
α Antares	1	8	2	27	23	ditto	4	32,2 S	16	14	55,2	3,7	25	51	2 S	+ 9

Note,

Note, That the Apparent Longitudes of the Stars will differ from their True Longitudes, when in or near Oppoſition to the Sun, about 20″ or ⅓ of a Minute, occaſioned by the Aberration, which is the greateſt when the Sun is in (☌ or ☍) Conjunction or Oppoſition to the Stars; but from thence it decreaſes to the Quadratures, where the Aberration becomes (0) it thence begins to increaſe again. Hence it is neceſſary to apply the Aberration, when conſiderable, in the following Manner; that is to ſay, deduct the Longitude of the Sun from the Longitude of the Star (adding 12^s to the Star's Longitude when the Sun's Longitude is the greater); then, if the Difference of Longitude (of the *—⊙) be leſs than 3^s, or greater than 9^s, ſubtract the Aberration from the True Longitude of the Star, and the Difference will be the Star's Apparent Longitude. But if the *—⊙ be more than 3^s, or leſs than 9^s, then add the Aberration as obtained by the following Table. It being known that Light takes 8′ 7″½ of Time in paſſing from the Sun to the Earth, in which Time the Sun deſcribes an Arc of 20″ in her Orb; and this is the greateſt Aberration of the Stars of a Latitude leſs than Five Degrees.

Aberration in Longitude and Latitude of the Stars.

Star's Lat.	Aber. in Long.	Aber. in Lat.	Long. of the *—⊙		Long. of the *—⊙		Aberrat.	Long. of the *—⊙	
°	″	″	s	°	s	°	″	s	s
0	20,0	0,0	0	0	6	0	20,3	6 and	12
2	20,0	0,7	1	0	7	0	17,6	5 and	11
4	20,0	1,4	1	10	7	10	15,5	20	
6	20,1	2,1	1	20	7	20	13,0	10	
8	20,2	2,8	2	0	8	0	10,1	4 and	10
10	20,3	3,5	2	10	8	10	6,9	20	
			2	20	8	20	3,5	10	
			3	0	9	0	0,0	3 and	9
			—Aber.		+Aber.		Aberrat.	+Aberrat.—	

Note, In the laſt Column, the Difference of Longitude of the Sun and Star, on the Left Hand upwards, gives the Aberration additive as noted at the Foot; but the Difference of their Longitudes being taken on the Right Hand upwards, gives the Aberration deductive, or to be ſubtracted from the True Longitude, to get the Apparent Longitude, which is the Longitude (or the Difference of Longitude of a Star from the Sun or Moon) by Obſervation.

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The Manner of making Obſervations in reſpect of taking the Diſtances of the Sun and Moon, and of the Moon and Stars, with the Altitudes and Times, is ſufficiently explained in the following Rules and Examples.

To find the Longitude of a Ship at Sea by Obſervation of the Diſtances of the Sun and Moon (taken with a Hadley's Quadrant) or of the Diſtance of the Moon and a fixed Star of a ſmall Latitude, as in the foregoing Table.

The Quadrants made for taking Altitudes being very troubleſome to hold in ſo many different Poſitions (as theſe Kinds of Obſervations require) therefore I have contrived an additional Part, which is readily put to a Quadrant; whereby the Obſerver may hold it in any (oblique) Poſition with the ſame Eaſe as in the common vertical one of taking Altitudes.

The Price of this Apparatus is 15 s.

Hadley's Quadrants, recommended for thoſe Obſervations, are ſold by the Author at the following Prices;

	l.	s.	d.
Thoſe for making Obſervations on the Sun and Moon ——	4	5	0
Ditto for Sun, Moon, and Stars, with a Teleſcope ——	5	0	0
Ditto with a Nonius Screw to the Index —— ——	5	10	6
Ditto with every Apparatus complete —— ——	6	6	0
Ditto the moſt complete, with Half-Minute Nonius Diviſions	7	7	0

To find the True or Apparent Time of an Obſervation.

Take Three or Four Altitudes of the Sun at One, Two, or Three Minutes aſunder, and from 8 to 10 or 12 Degrees of Altitude, when the Latitude and Declination are of different Names, and when the Latitude exceeds 30 Degrees; but if the Latitude be leſs than 30 Degrees, the Sun's Altitude may be taken at greater Heights: alſo if the Latitude and Declination are of the ſame Name, then the Altitudes may be taken from 10 to 40 or 50 Degrees, according to the Latitude of the Ship or Place; and may frequently be taken near the Prime Vertical (or E. and W. Azimuth) where the Sun and Stars riſe and fall the quickeſt, and therefore the beſt for thoſe Purpoſes.

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Star's Lat.	Aber. in Long.	Aber. in Lat.	Long. of the ✱—☉		Long. of the ✱—☉		Aberrat.	
°	″	″	s	°	s	°	″	s s
0	20,0	0,0	0	0	6	0	20,3	6 and 12
2	20,0	0,7	1	0	7	0	17,6	5 and 11
4	20,0	1,4	1	10	7	10	15,5	20
6	20,1	2,1	1	20	7	20	13,0	10
8	20,2	2,8	2	0	8	0	10,1	4 and 10
10	20,3	3,5	2	10	8	10	6,9	20
			2	20	8	20	3,5	10
			3	0	9	0	0,0	3 and 9
			—Aber.		+Aber.		Aberrat.	+Aberrat.—

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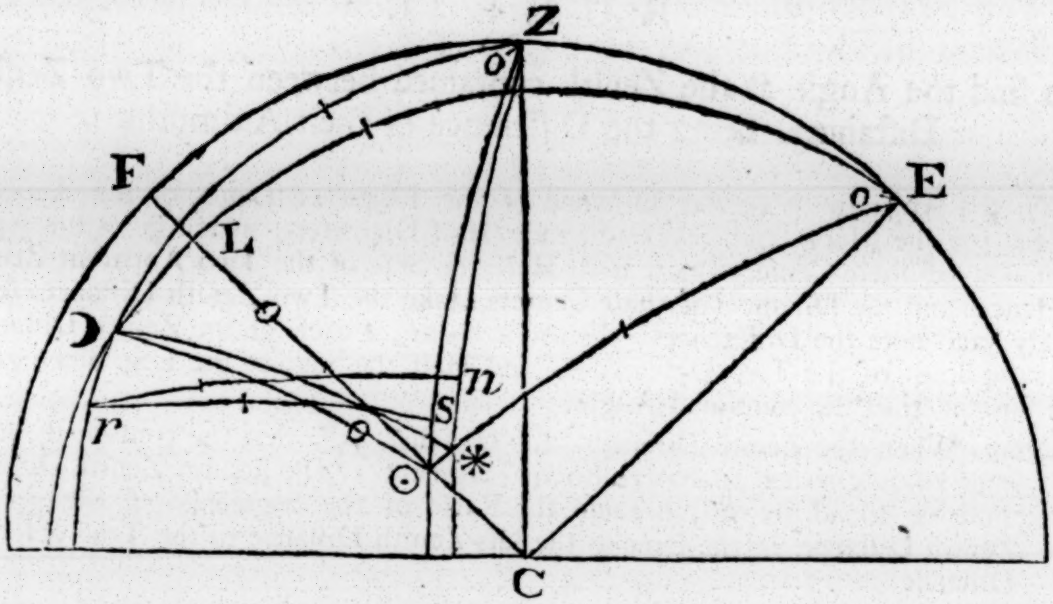
Take Three or Four Altitudes of the Sun at One, Two, or Three Minutes aſunder, and from 8 to 10 or 12 Degrees of Altitude, when the Latitude and Declination are of different Names, and when the Latitude exceeds 30 Degrees; but if the Latitude be leſs than 30 Degrees, the Sun's Altitude may be taken at greater Heights: alſo if the Latitude and Declination are of the ſame Name, then the Altitudes may be taken from 10 to 40 or 50 Degrees, according to the Latitude of the Ship or Place; and may frequently be taken near the Prime Vertical (or E. and W. Azimuth) where the Sun and Stars riſe and fall the quickeſt, and therefore the beſt for thoſe Purpoſes.



From the adjacent Figure ariſe the Inveſtigations of the Three General Rules, whereby the Difference of Longitude of the Two celeſtial Objects (as the ⊙ and ☽ or the ☽ and ✱) are deduced from Obſervation. For Example; Let Z be the Zenith, E the Pole of the Ecliptic, and FL⊙C the Ecliptic; then,

1. In the Triangle *r*SZ is given Z*r* and ZS, the Apparent Zenith Diſtance of the ⊙ and ☽.
   To find the contained Angle Z, their Difference of Azimuth.

2. In the Triangle Z☽⊙ is given Z☽ and Z⊙, and the contained Angle Z, to find ☽⊙, the Orbit Difference of Longitude of the ☽ from the ⊙, or the True Diſtance, per Obſervation.

3. In the Triangle L☽⊙ is given L☽, the Latitude of the Moon, and ⊙☽ the True Diſt. per Obſervation.
   To find L⊙, their obſerved Difference of Longitude.
   But when the Diſtance of the Moon and a Star (✱) is obſerved, then their Diff. of Longitude muſt be found at the Pole of the Ecliptic: for let *n* be the Appt. Place of the Star, and ✱ its True Place; then in the Δ E✱☽ are given the Three Sides to find the ∠ at E; that is, ⊙✱ the Lat. N. of the ✱, and ☽L the ☽'s Lat. S. Now in Δ ☽E✱ is given ☽E = 90° + ☽'s Lat. ✱E = 90° — ✱'s Lat. and ☽✱ their True obſerved Diſtance, to find the ∠ E, their Difference of Longitude, as per Rules following.
   N.B. If the Latitude of the Moon be of the ſame Name as the Star's, then 90° — ☽'s Lat. = ☽ from the Pole E.

RULE I.

To find the Angle at the Zenith contained between the Two Zenith Diſtances, being the Difference of their Azimuths.

To the Apparent obſerved Diſtance of the Edges or Limbs of the Sun and Moon (or the Moon and Star) add their Half Diameters, which gives the Appt. Diſtance of their Centers; now from Half the Sum of the Two Apparent Zenith Diſtances and the Diſtance of their Centers, take the Two Zenith Diſtances ſeparately, and note the Differences: then to s. co. ar. of each of the Zenith Diſtances add the Sines of the Two Differences, and Half the Sum of the Log. Sines gives the Sine of Half the contained Angle.

Note, When the Zenith Diſtances are leſs than 45°, that the contained Angle muſt be determined to 10″; alſo the Segments of the greater Zenith Diſtance muſt be found to 10″, becauſe the Ratio of the Segments of the greater Zenith Diſtance is the ſame as the leſs Zenith Diſtance to the True obſerved Diſtance.

RULE II.

To find the True Diſtance obſerved.

Add the Refraction to the Zenith Diſtance of the Sun or Star, and the Sum is the True Zenith Diſtance;

And from the Zenith Diſtance of the Moon take the Difference of the Parallax and Refraction, and the Remainder is the True Zenith Diſtance of the Moon:

Then, to the Tan. of the leſs True Zenith Diſtance add the Co-ſine of the contained Angle, and the Sum of the Logs. will give the Tan. of an Arc, which call A; and from the greater True Zenith Diſtance take the Arc A, and the Arc B will remain. Remark, if the contained Angle exceed 90 Degrees, then take its Supplement to 180°; and when this happens, add the Arc A to the greater True Zenith Diſtance, and the Sum is the Arc B.

Then to the Co-ſine, Co. ar. of A add the Co-ſine of B, and the Co-ſine of the leſs True Zenith Diſtance; the Sum of theſe Logs. will give the Co-ſine of the True Diſtance obſerved.

RULE III.

To reduce the True Diſt. obſerved to the Diff. of their Longitudes.

For the Sun and Moon.

To the Log. of the True obſerved Diſtance add the Co-ſine, Co. ar. of the Moon's Latitude, and the Sum is the Log. of the Co-ſine of the Difference of their Longitudes by Obſervation.

For the Moon and Star, ſee the Example for June 14, 1761, N° III.

ARTICLE I.

To find the True Tabular Longitude, Latitude, Diameter, and Parallax of the Moon; alſo the Longitude and Diameter of the Sun, with the hourly Motions and Refractions of the Sun and Moon, &c.

Take out of the Tables Two Longitudes of the Moon before the Time of the Obſervation and Two Longitudes after, and find their firſt and ſecond Differences; then work as in the following Examples.—Note, You muſt always aſſume the Longitude of the Ship from the Place to which the Tables are adapted, as near as you can, from the Ship's Account; which Longitude convert into Time at 15° to the Hour, as per Table; and if your aſſumed Longitude of the Ship be Weſt of the Place aſſumed from, then add the aſſumed Longitude in Time to the True Time at the Ship, and you will have the True Time at the Meridian of the Tables: but if the Ship be aſſumed E. of the Place aſſumed from, then ſubtract the Time of the aſſumed Longitude from the Time of the Obſervation, and the Remainder will be the Eſtimate Time at the Meridian of the Tables; to which Time calculate the True Longitudes of the Sun and Moon, &c. as in the Examples following.

REMARK I.

If the ⊙ or ✱ be W. of the ☽ (that is, if the Longitude of the ☽ be greater than that of the ⊙ or ✱) and the obſerved Diſtance or Difference of Longitude greater than that calculated, then add the proportional Quantity to the Longitude aſſumed: but if the ⊙ or ✱ be E. of the ☽ (that is, if the Longitude of the ☽ be leſs than that of the ⊙ or ✱) and the obſerved Difference of Longitude be greater than the calculated Longitude, then ſubtract the proportional Quantity from the Longitude aſſumed, and the Reſult will be the True Longitude of the Ship at the Time of Obſervation.

N. B. If the obſerved Difference of Longitude be leſs than the calculated, then uſe the contrary.

Obſerve, that by calculated Longitude I mean the Longitude obtained from an Ephemeris, or from Aſtronomical Tables computed.

The regular Steps to be taken after the Obſervation is made.

1. To find the True Time (that is, the Solar or Appt. Time) of the Obſervat.
2. To find the True Longitude, Diameter, and Hourly Motion of the ☉ (or ✳) per Art. I.
3. To find the True Longitude, Latitude, Diameter, Parallax, and Hourly Motion of the ☽.
4. To find the Angle at the Zenith in the Apparent Δ, per Rule I.
5. To find the True obſerved Diſtance by the True Δ, per Rule II.
6. To find the True Difference of their Longitudes, per Rule III.
7. To find the Longitude of the Ship by the Reſult of the Obſervation, obſerve the following Article.

ARTICLE II.

Take the Difference between the calculated and obſerved Longitude, and then ſay,

As the hourly Motion of the ☽—☉ (that is, the ☽'s hourly Motion leſſened by the ☉'s hourly Motion) is to 15 Degrees of terreſtrial Longitude, ſo is the Difference of the calculated and obſerved Longitudes to the proportional Quantity, which apply as directed in the foregoing Remark, and you will have the Longit. of the Ship at the Time of the Obſervation: to which if you apply the Longitude that the Ship has made to or from Noon, you will have the Longitude of the Ship at the Noon of the given Day. But if the Obſervation be of the ☽ and a ✳, then ſay, as the hourly Motion of the ☽ : 15° Long. : : the Difference of the Longitudes computed and obſerved : the proportional Quantity, which apply as above directed.

The Proportion in Words:

As the hourly Motion of the Moon from a Star, or from the Sun, is to Fifteen Degrees of Longitude of the Equator, ſo is the Difference of the calculated and obſerved Longitudes to a proportional Quantity to be added or ſubtracted to or from the aſſumed Longitude, as directed in the Remark foregoing.

REMARK II.

When you conceive yourſelf to be near the Meridian of your Tables (as ſuppoſe London) then you may ſuppoſe yourſelf under the Meridian to which the Tables are adjuſted; and then obſerve, that if the Diſtance of the Sun, or Star and the Moon, be increaſing, and the obſerved Longitude greater than the computed, then the proportional Quantity ariſing will be Weſt Longitude; but if leſs, Eaſt Longitude. Likewiſe, if their Diſtances be decreaſing, and the Longitude by Obſervation the greater, then the proportional Quantity will be Eaſt Longitude, but if leſs, Weſt Longitude.

REMARK III.

Always aſſume your Difference of Longitude in Time ſo as to make even Minutes without Seconds, when applied to the True Time at the Ship; alſo that the Minutes may be ſome aliquot Part or Parts of an Hour; whereby you may more readily obtain the Increaſe of the Longitude of the Sun and Moon in the Time required.

Thus $\frac{2}{5}$ of any Number is obtained by multiplying the Number by 2 and dividing that Product by 5, the Quotient is the Anſwer. Alſo $\frac{9}{10}$ of any Number may be had by multiplying by 9, and cutting off one Figure towards the Right-hand.

Note, If the Sun be Weſt of the Moon, or the Moon Weſt of the Star, then the Quadrant muſt be brought into a Poſition ſo as to bring the Sun to the Moon, or the Moon to the Star (in the ſame Manner as you do the Sun to the Horizon); and in this Caſe you muſt turn the Face of the Quadrant upwards: but when the Sun is Eaſt of the Moon, or the Moon Eaſt of the Star, you muſt then turn the Backſide of the Quadrant uppermoſt; that is, always ſet the Head of the Quadrant towards the more luminous Object, and the Limb or Arch towards the Object to which the other is to be brought ſo as to appear to coincide.

The following Columns contain the Year, Month, and Day of the Month; the Latitude and Longitude of the Ship by Obſervation; alſo the Longitude by Account, on a Voyage in the Oxford Indiaman, Captain Webber, from St. Helena, (in Lat. 16° South, and Long. 5° 54′ Weſt) The Longitudes obtained from Obſervations were by taking the Diſtance of the Sun and Moon, or the Moon and a Star, by a Hadley's Quadrant, and computed on board by Robert Waddington.

1761		Latitude perObſer. ° ′	Long. per Obſervat. ° ′	Longit. per Acc^{t} ° ′	
July	6	10 06 S.	17 18W	16 52W	per the obſerved Diſtance of the ⊙ & ☽
	7	9 14	18 56	18 41	per ditto — the mean of 2 Obſervat.
	8	8 34	20 6	20 15	per ditto — the mean of 3 ditto.
	9	7 50	21 39	21 38	per ditto — the mean of 2 ditto.
	10	6 56	23 7	23 26	per the ☽ & Spica, the mean of 3 Obſer.
	11	6 06	25 20	25 08	per ditto — ditto 2 ditto.
	12	5 11	27 51	27 01	per ditto — ditto 2 ditto.
	13	4 9	28 48	28 33	per ditto — ditto 2 ditto.
	15	3 28 S	31 00	30 22	per ditto — ditto 1 ditto.
	25	7 30 N	29 40	28 17	per ditto — ditto 3 ditto.
	27	9 57	28 37	27 23	per ditto — ditto 3 ditto.
	28	11 7	27 56	27 05	per ☽ & ⊙ — ditto 3 ditto.
Auguſt	3	14 37	29 32	28 25	per ditto — ditto 2 ditto.
	4	15 47	30 30	28 12	per ditto — ditto 2 ditto.
	5	16 09	31 54	29 23	per ditto — ditto 5 ditto.
	23	36 30	35 41	34 12	per ditto — ditto 4 ditto.
	25	36 35	35 30	33 49	per ditto — ditto 4 ditto.
Septem.	2	40 12	35 20	33 32	per ditto — ditto 4 ditto.
	4	39 55	32 46W	31 12	per ditto — ditto 4 ditto.
Ditto 18th at 3½ P.M. Long. made per Acc. ſince 4th			30 02 E	29 58	Per Obſervation of the 2d Sept. the Ship's Longitude was 35° 20′W Made ſince to the 18th 32 18 E
Longit. in per Obſerv.			2 44W	1 14W	Longit. in per this Obſervat. 3 02W
Longitude of Portland			2 48W	2 48W	Ditto Portland — 2 48W
Error of Long. per Obſ.			0 04	1 34 E	Error of Longit. per this, only 0 14

Note. The 18th of September, at 3 Hours and a half Afternoon, Portland bore due North of us; I then cloſed my Account of the Voyage, which ſtood as above.

I am informed that moſt of the Ship's Account in Company were 5 or 6 Degrees in Longitude Error to the Eaſt.

The Reaſon of my Account (both outwards and homewards) being nearer than others, was owing to my frequent making Allowance for the Set of Tides, as I conceived moſt agreeable to philoſophical Principles.

The following is an Example of an Obſervation (for finding the Longitude) which was made and computed on board the Oxford Indiaman, Capt. WEBBER, by R. WADDINGTON, now Teacher of Mathematics at the Mathematical Academy in Three Tun Court, Miles's Lane, near the Monument, London.

1761, per Watch,					Diſt. of the Edges ☉ and ☽ obſerv.		☽'s Appt. Alt.		☉'s Appt. Alt.		
	d	h	′		°	′	°	′	°	′	
Sept.	2	5	19	P. M.	49	07					
1ſt Obſer.			27		49	9	31	00	13	01	Refⁿ 4′,0
			37		49	13					
2d Obſer.			43		49	15	28	57	9	59	Refⁿ 5′,2
			49		49	16					
3d Obſer.			56		49	19	27	17	7	30	Refⁿ 7′,0
			60		49	21					
			68		49	23					
			77		49	26					

9 | 436 Sum of the Minutes 149, which divided by 9, the N° of obſerved Diſtances, gives $5^{h}\ 48',44$, the mean Time, and $49^{\circ}\ 16',56$ the mean Diſtance.

Now to reduce this Mean of the Times and Diſtances to the Time of an Obſervation; that is, to the Time when the Altitude of the Sun and Moon were taken;

thus, from 77′ | and from 26′
take 19 | take 7

Remains the T. of making the Obſervation. 58 | Remains 19 the Increaſe of Diſt. of the ☽ from the ☉ in that Time.

And 58 divided by 19, quotes 3 +; hence the Ratio of the Time, to the Increaſe of Diſtance, is as 3 to 1 nearly;

Therefore

	h	′		°	′	
Therefore to	5	48,44	and	49	16,56	
add		7,56	and		2,52	= $\frac{1}{3}$ of the Time.
Hence the Ti. which may be called the Obſervation.	5	56	and	49	19,08	the Diſtance.
Alſo from	5	48,44	and	49	16,56	
take		5,44	and		1,81	= $\frac{1}{3}$ of the Time.
Remains the Mean of the T. red.	5	43,0	& Diſt.	49	14,75	which may alſo be

called an Obſervation: then find the True, Appt. or Solar Time of the Obſervat. from the Alt. of the Sun, taken at that Time by an Aſſiſtant.

The Latitude of the Ship, at the Time of this Obſervation, was 40° 8′ N. ⊙'s Decl. 7° 40 N. by allowing for the ſuppoſed Time, Afternoon, at the Meridian of the Tables, or Ephemeris, intended to compute the Difference of the Longitudes of the Sun and Moon from; which I generally did from the Paris Ephemeris; and ſometimes from both the Ephemeris and the Aſtronomical Tables of Mr. Morris, with Mr. Mayer's Equations applied; the Reſults of both are in ſome of the Examples following:

	h	′	″
The true Time of the 1ſt Solar Alt. computed, is	5	18	00
To which I add the Time, per Watch, to the 2d Ob.		16	
The Sum is the Time of the 1ſt reduced to the 2d	5	34	00
The Time of the 2d Obſer. per Calculation	5	33	57
The Time of 3d is 5h 47′ 8″, redu. to the 2d is	5	34	8

Hence I take the true Time of the Obſervation 5h 34′ to which Time I aſſume my Difference of Longitude to be 2 26 = 36° 30′ W. from the Meridian of Paris = 8 00 the Time to which I find the Longitudes of the Sun and Moon, &c. as follows:

☽'s Tr. Lon. at Tr. Noon.							1ſt Diffs.			2d Diffs.		
1761,	D.	H.	s	°	′	″	°	′	″	′	″	
Sep.	1	12 =	6	19	22	35	6	37	36	4	31	
	2	0 =	6	26	00	11	6	33	5			
	2	12 =	6	32	33	16	6	26	55	6	10	
	3	0 =	6	39	00	11						
										10	41	Sum
							Mean 2d Dif.			5	20 ½	ditto

☽'s Incr. of Lon. in 12^h = 6° 33′ 05″	of the Time wherein the Obſervation was made.
in 1 = 0 . 32 45,42	which is the true hourly M. of the ☽ at 6 P. M.
Which multiply by 8	the N° of Hours P. M. of the Obſervation.

Product =		4	22	03,36
The variable Qty of mean 2d Diff.			+	35,33
The true Incr. of the ☽ in Lon.		4	22	38,7
To which add ☽'s Lon. Sep. 2, =	6.	26.	00	11,0
True Longitude of the ☽	7.	0.	22.	49,7
True Longitude of the ☉	5.	10.	26.	54,0

Diff. of Long. by Calculation = 49°. 55′. 55″,7

☉'s tr. Longitude at tr. Noon.

	s	°	′	″		′	″
Sep. 2, =	5	10	7	30	daily Diff.	58	12
For 8^h add			19	24	$\frac{1}{3}$ = 8^h =	19	24
☉'s tr. Lon.	5	10	26	54			

☽'s Lat. 2° 0′ 19″ N. Hor. Paral.	57′	4″	which,
per Table, gives for 29° Alt. the Paral.	49	50	

☽'s Hor. Diam. per Ephemeris	31′	9″
Add for Alt. of 29° the Appt. Incr.		15
☽'s Appt. Diam.	31	24
☉'s ditto	31	50
Half Sum of the Diameters	31	37

The

The true Lat. of the ☽ is thus found:

	☽'s Lat. ° ′ ″	1 Diff. ′ ″	2 Diff. ′ ″
Sep. 1 =	3 19 33 N.		
		58 16	
2 =	2 21 17		+5 56
		64 12	
3 =	1 17 5		+1 54
		66 6	
4 =	0 10 59		

Mean 2d Diff. 3 55 gives, per Table — 25″,5: hence for $8^h = \frac{1}{3}$ of 24^h; I therefore take $\frac{1}{3}$ of 64′ 12″ which is 21′ 24″ the Mean Decreaſe of the ☽ in Latitude in 8^h.

For the variab. Quty. of the ☽'s Decr. — 25,5

Rem. the tr. Decr. of the ☽ in Lat. = 20 58,5

	° ′ ″
Hence from	2 21 17
Take	0 20 58
Rem. the tr. Lat.	2 0 19 N.

	h	″	
Variable Quantity	for 7 ½	= —27,5	of ☽'s Long. per Tab. of 2d Diff.
Ditto	for 8 ½	= —24,5	
The Difference		= — 3,0	Which ded. from the Mea. hour. Mo. of the ☽ becauſe the Mo. of the ☽ is dec. as by 2d Diff.

For the hourly Motion of the ☽ from the ⊙.

☽'s Mean Increaſe of Longitude in an Hour, is	32 45,42
Subtract the Difference of the variable Quantities	3,0
Remains the ☽'s true hourly Motion	= 32 42,4
The ⊙'s hourly Motion	= 2 25,6
Hourly Motion of the ☽ from the ⊙	= 30 16,8 = 30,′28

To

To find the Difference of the Longitude of the Sun and Moon, by the Obſervation, per Rule I. to find their Difference of Azimuths.

	° ′ ″		° ′ ″	
Appt. Diſt. of the Edges of the ☉ and ☽ per Obſervation			49 14 45	
Add half the Sum of their Diamrs.			31 37	
Appt. Diſt. of their Centers			49 46 22	
☽'s Appt. Z. Diſt.			61 3 0	its s. co. arith. = 0,0579709
☉'s Appt. ditto			80 1 0	its s. co. arith. = 0,0066263
Sum of the Sides			190 50 22	s. of 15 24 11 = 9,4242403
Half Sum	95 25 11	and	95 25 11	s. of 34 22 11 = 9,7516877
	—61 3 0	and	—80 1 —	Sum = 19,2405252
Difference	34 22 11	and	15 24 11	s. of 24 39 10 = 9,6202626

its double = 49 18 20 the ∠ at the Zenith.

	°	′	″
☽'s Appt. Z. Diſt.	61	03	
Par. of Alt. 49′,8 Refr^{n} 1′,8			
The Diff. ſub.		48	
☽'s tr. Z. Diſt.	60	15	
☉'s Appt. Z. Diſt.	80	01	
Ref^{n} add		5	20
☉'s tr. Z. Diſt.	80	6	20

	°	′	″	
Now to the T. of the tr. leſſer Z. D.	= 60	15	—	= 10,2429480
Add the co. ſ. of ∠ at the Zenith	49	18	20	= 9,8142642
Which gives the T. of A (the 4th Arc)	= 48	45	48	= 10,0572122
Which take from greater tr. Z. Diſt.	80	6	20	
Rema. Arc B (the 5th Arc)	= 31	20	32	

	°	′	″	co-ar.
To the co-ſ. of Arc A.	48	45	48	= 0,1810020
Add { The co-ſ. of Arc B.	31	20	32	= 9,9314964
Add { And the co-ſ. of the leſs tr. Z. D.	60	15		= 9,6956712
The Sum is the co-ſ. of the true Orbit Diſt. obſerved	49	59	20	= 9,8081696
To which add the co-ſ. co-ar. of the ☽'s Latitude	2	0	20	= 0,0002661
Which gives the co-ſ. of the Diff. of Long. per Obſer.	49	57	33	= 9,8084357
Difference of Longitude, by Calculation	49	55	56	
Obſerved Long. greater than the aſſumed by		1	37	as per Obſer.
		= 1,62		

Laſtly. As the hourly Mo. of the ☽ from the ☉, 30′,28 is to 15° of Long. ſo is the above Difference 1′,6 to 0° 47′; the Longitude to be added to that aſſumed, viz.

	°	′	
To	36	30	W. aſſum'd
Add	0	47	as per Remark
Long. from Paris	37	17	at the Ti. of the Obſer.
Paris to London —	2	25	W. deduct.
Long. from Lond.	34	52	W.
The Ship made ſince Noon }	+	9	E. add
Long. of the Ship	35	01	W. at Noon, 2d Sept. 1761
Ditto	35	10	by a more Lax Calculation

made at Sea, as publiſhed in the General Magazine for July 1762.

Thus 1′,6
× 15
80
16
30′,28) 24,00 (0° 47′,5
× 60
144000
12112
22880
21196
16840
15140

R E M A R K. Since it often happens, that the varying Poſition of the Objects are ſuch, as not to admit of taking the Mean of the Times and Diſtances for an Interval of 45 Minutes, or an Hour (although it was in the Example of the 2d of September). ~~But~~ Therefore I would recommend (in a general Way of Practice) not to make uſe of Intervals of Time, that exceed 20, 25 or 30′ at the moſt, to take the Mean thereof for an Obſervation. When Circumſtances will not admit of taking the Obſervations in this Manner, then take the Mean of ſuch as will admit thereof; and thoſe Obſervations that will not, let be computed alone; which done, take the Mean of the Longitudes ariſing, for the Longitude of the Ship, by Obſervation.

	h	′	″		°	′	″
The Mean of the three firſt Obſer. is	5	27	40	and	49	9	40
Ditto of the 3d, 4th, and 5th ditto is	5	43	0	and	49	14	40
Ditto of the five laſt ditto is	6	2	0	and	49	21	0

Now theſe being reduced to the Times that the Altitudes were taken; or the Altitudes reduced to thoſe Times, and then ſeparately computed; the Mean of the Longitudes reſulting will be nearly the ſame as that obtained by the Mean of the whole, as in the Example.

	per Watch h	′		Diſt. of Edges of ☉ & ☽ °	′	
1761, Sept. 4th at	4	7	P. M.	72	15	
at	4	11		72	17	
at	4	20		72	20	☽'s Alt. 29° 43′, ☉'s Alt. 26° 40′
at	4	34		72	24	Ap.t. Z.D. 60 17 ditto 63 20

Sum of Min. 72 ditto 76 which divided by 4, the N° of obſerved Diſt. gives 4 18 P.M. & Diſt. 72 19; now either the Altitudes muſt be reduced to this Time; or this Time and Diſt. muſt be reduced to the Time that the Altitude of the ☉ and ☽ were taken. And ſince no other Altitudes were taken (at proper Intervals of Time) I am obliged to reduce the Time and Diſtance, which I do as follows: Thus, the Minutes of the Time at the laſt obſerved Diſtance,
is 34′ and the Min. of Diſt. 24′ from which I take the Min. of the firſt Ti.
7 and Diſtance 15

Re. 27 and 9

Now dividing the greater by the leſſer, viz. 27 by 9 gives 3′ of Time to 1′ of Diſtance.

	h	′			°	′	″
Hence to	4	18	and	to	72	19	0
add		2	and ⅓ thereof			0	40
Gives the Ti.	4	20	and		72	19	40 for a Mean of the obſerved Diſt.

Note. The Altitude of the Sun, at the Obſervation, being a little uncertain, occaſioned by the Horizon being hazy, and the Sun not in the beſt Poſition for to determine the Time (for the Sun paſſed the prime Vertical at 11° Altitude) which muſt always be accurately obtained, otherwiſe a very conſiderable Error would accrue in the Reſult of the obſerved Longitude. Hence at 4^{h} 52′ per Watch, I obſerved the Altitude of the Sun to be 20° 35′ 30″, the Dip and Refraction allowed.

	°	′	″		°	′			°	′	
Z. Diſt.	69	24	30	Decl.	6	57	N. and the	Ship's Lat.	39	55	N.
				Co-Decl.	83	3		Co-Lat.	50	05	

For

For the Time. ° ′
Co-Decl. 83 03 its s. co-ar. 0,0032029
Co-Lat. 50 5 its s. co-ar. 0,1152168
Co-Alt. 69 24 | s. of 18 13=9,4950046
| s. of 51 11=9,8916242
Sum 202 32 |
101 16 and 101 16 | Sum = 19,5050485 ° ′ ″
— 83 3 — 50 5 | Half do. 9,7525242 = s. of 34 26 44 h ′ ″
| Double is the ∠ at the Pole 68 53 28 = 4 35 34
Diff. 18 13 and 51 11 |

From 4ʰ 52′ the Time, per Watch, at the ⊙'s Obſer.
Take 4 20 the Time of the Obſer. of ⊙ and ☽

Rem. 0 32 which ſubtract 32 0

Remains the true Time of Obſer. 4 03 34
Aſſume the Lon. in 34° 6′ ½ W. = 2 16 26

The Time to compute to (Time at Paris) = 6 20 0

	d	h	s	°	′	″	1ſt Diff.			2d Diff.	
							°	′	″	′	″
Sept.	3	12 =	7	15	21	6					
							6	15	58		
	4	0 =		21	36	44				— 4	42
							6	10	56		
	4	12 =		27	47	40				— 4	22
							6	6	34		
	5	0 =		33	54	14					

Mean 2d Diff. 4 32

h ° ′ ″
☽ in 12 = 6 10 56
in 6 = 3 5 28
in 1 = 0 30 54,7 —
in 20′ = ⅓ = 0 10 18,2 +

in 6ʰ 20′ = 3 15 46,2
Variable Quantity for 5ʰ 20′ add 33,8

☽'s true Increaſe of Lon. in 6ʰ 20′ 3 16 20,
To which add the ☽'s Lon. the 4th at Noon 7 21 36 44,

Gives the ☽'s true Lon. at the Time of the Obſer. 7 24 53 04,

	h	′	″
⊙ in	24 =	58	17,0
in	6 =	14	34,25
in	1 =	2	25,71
in	20′ =	0	48,6–
in 6^h 20′ =		15	22,8

	d	s	°	′	″
⊙'s Lon.	4 =	5	12	3	57
Add				15	23
⊙'s true Lon.		= 5	12	19	20
☽'s ditto		7	24	53	04
Diff. of Lon.		= 2	12	33	44
Or			72	33	44

For the Latitude of the Moon.

☽'s Latitude.

	d	°	′	″	′	″	′	″
Sept.	3 =	1	17	5 N.				
					66	6		
	4 =	0	10	59 N.			— 0	43
					65	23		
	5 =	0	54	24 S.			— 4	1
					61	22		
	6 =	1	55	46 S.				
						The Mean	= 2	22

	h	′	″	
	24 =	65	23	
	6 =	16	21	
	1 =	2	43,5	
	20′ =	0	54,5	
	6^h 20′ =	17	15,5	the Lat. the ☽ has made S.
Var.Quty.for M. 2d Diff. in do.		+	17,5	
		17	33	the true Diff. of Lat. made S.
☽'s Latitude the 4th at Noon		10	59 N.	
True Latitude of the ☽		6	34 S.	

For the hourly Motion.

Mean 2d Diff. 4′ ½ for 6h gives		34″
Ditto for 6h 40′ =		32 ½
Diff. add		1,5
To the M. Mo. in 40′ =	20′	36,5
☽'s true Mo. in 40 =	20	38
☉'s ditto in ditto	1	37
Diff.	19	1

Hor. Par. 55′ 36″ Diam.	30′	22″
Bor ☽'s Alt. add		15
☽'s Appt. Diam.	30	37
☉'s ditto	31	51
Sum	62	28
Half Sum of the Diamrs.	31	14

	°	′	″	
Diſt. of the Edges obſerved	72	19	40	
Add Half the Diameters		31	14	per Rule I.
Appt. Diſt. of the Centers	72	50	54	
☽'s Appt. Z. Diſt.	60	17		
☉'s ditto	63	20		
	196	27	54	

	98	13	57	and	98	13	57
—	60	17	—	and	63	20	—
	37	56	57	and	34	53	57

its s. co-ar.	0,0612365
its s. co-ar.	0,0488410
s. Diff.	—9,7574977
s. Diff.	—9,7888484
	19,6564236
s. 42° 19′ 21″½ =	9,8282118
× 2	
84 38 43 the con. ∠ or Diff. of Azi.	

Hor. Par. 55′ 36″ gives the ☽'s Par. of Alt.		48′	00″
Refraction		1	40
Difference		46	20
☽'s Appt. Z. Diſt.	60	17	00
☽'s true Z. Diſt. =	59	30	40
☉'s true ditto	63	21	50

Preparation to Rule II.

Per RULE II.

	°	′	″		
To the Tan. of the leſs true Z. Diſt.	59	30	40	=	10,2300441
+ the co-ſ. of the cont. ∠	84	38	43	=	8,9699819
The Tan. of A	9	0	23	=	9,2000260
True greater Z. D.	63	21	50		
Arc B	54	21	27		
co-ſ. of A. co-ar.				=	0,0053877
co-ſ. of B.				=	9,7654642
co-ſ. leſs true Z. D.				=	9,7053259
co-ſ. true Diſt. obſerved	72°	34′	54″	=	9,4761778
co-ſ. co-ar. ☽'s Lat.	0	6	34	=	0, 8
co-ſ. of the Diff. of Lon.	72	34	53	=	9,4761786
Diff. of Lon. per Comp.	72	33	44		
The obſerved greater, by		1	9		

As the Motion of the ☽ from the ☉ in 40′ is to 10° of Lon. ſo is the Diff. to the 4th Proportional; that is,

As 19′,0 : 10° : : 69″ : 36′½ which add to aſſumed Lon.

	°	′	
Hence to	34°	6′ ½ W.	N. B. That as Min. are to Degrees ſo are Seconds to Minutes.
Add		36 ½	
	34	43	W. Lon. of the Ship at the Ob. from the Meridian of Paris
Lon. made ſince Noon		24	E. add
	35	7	
Subtract	2	25	Paris to London
Lon. of the Ship	32	42	W. from London
Ditto made to the 18th, at 3 and a half P.M.	29	58	
Remains	2	44	

	°	′	
Portland Lon.	2°	48′	W.
Lon. in per Obſervation	2	44	W.
Error in Lon. only		4	

Note, By Calculation from Aſtronomical Tables,

			′	″		′	″	
The hor. Paral. of the ☽ =			55	36	Hor. Diam.	30	18,4	
Hor. Diam. at 33° of Alt.			30	33,2	and	6	37	Lat. S.
☉'s ditto			51	51,5				
			62	24,7				
Half the Diameters			31	12,3				
Hourly Mo. of ☽ from ☉			28	31,0				
True Long. of ☽	7	24	53	10				
Ditto of the ☉	5	12	19	19				

Diff. of their Long. = 72° 33 51, which differs only 7″ from that obtained by the foregoing Method from the Paris Ephemeris.

Here follows ſome neceſſary Remarks in making the Obſervations, as in the following Examples, whereby it appears that great Care ought to be had of the Altitudes which are taken by Aſſiſtants: I always examined thoſe Altitudes, and rectified them as in the Example below, where-ever Opportunity would admit; which I adviſe always to be done when poſſible, otherwiſe a very conſiderable Error may be committed.

July 9, 1761, in the Latitude of 7° 50′ S.

Per Watch,		Diſt. ☉ & ☽		☽'s Appt. Alt. taken by an Aſſiſtant.		☉'s Appt. Alt. taken by an Aſſiſtant.	
h	′	°	′	°	′	°	′
At 2	1	96	46				
	4½		47½				
	9½		50	30	5	44	22
	15		52	31	37	43	20
	20		53½	33	3	42	17
	5) 50		5) 249				
The Mean 2	10 and	96	49,8				

19′ Time of making the Obſervation.
7½ Increaſe of Diſtance in that Time.
Hence the Time to the Increaſe of Diſtance is as 2½ to 1.

	h	′		°	′
I took the ☽'s Appt. Alt. at	2	11	which was	30	32
and at	2	13	ditto	31	2
		2	gives	0	30
and the Increaſe of the ☽'s Alt. in		1	was		15

Alſo

	h	′		°	′
Alſo I took the ☉ Appt. Alt. at	2	12	=	43	56
and at	2	17	=	42	54
		5	gives	1	2
Therefore		1	ditto	0	12,2 Dec. of Alt.

Hence I find my Lunar Aſſiſtant had made very bad Obſervations; for he differs the Altitude in $5'\frac{1}{2}$ 92′
and in 5 86
therefore in 1 17
which is 2′ Error per Minute.
} Therefore in 5′ of Time the Error in Altitude was 10′.
Note, The Decl. of the ☽ being about 7° S. and the Lat. 7° 50′ S.

Conſequently the Increaſe of Altitude might be 15′ in a Minute of Time; but it is impoſſible to be greater in any Circumſtance whatſoever.

	h	′		°	′	
Suppoſe I take the Time	2	10	and the Diſtance	96	49,8	obſerved, as obtained
by a mean Reſult		+	$\frac{1}{2}$ Diameter		31,1	
			Appt. Diſt. of the Centers	97	21,0	by increaſing the Diſt.

$\frac{1}{10}$ of a Minute, the Value of which being not worth Notice in reſpect of this large Diſtance.

	h	′		°	′		h	′		°	′
☽'s Alt. at	2	11	=	30	32	☉'s Alt. at	2	12	=	43	56
	—	1		—	15		—	2		+	24
Appt. Alt. at	2	10	=	30	17		2	10	=	44	20
whence ☽'s Appt. Z. Diſt.			=	59	43	and ☉'s ditto			=	45	40

Solar Time at the Ship $2^h\ 31'$; from hence the Longitude of the Ship at the Obſervation may be found to be 21° 42′ W. from London.

				Diſt. ☉ & ☽			☽'s Appt. Alt.		☉'s ditto.	
1761,	h	′		°	′					
Aug. 23, at	8	9	A. M.	88	28	the Edges.	°	′	°	′
1ſt Obſerv. at	8	30	ditto	88	20		47	30	40	36
Time to Noon	3	30	per Watch.							
ditto per ☉	3	9	16	The contained ∠ =	151	29,6 or Diff. of their Azi.				
Watch ſlow	0	20	44	its Supplement	28	30,4 } to be uſed in working by Rule II.				

2d Obſerv.

1761, Aug. 23.		h	'	"	Diſt. ☉ & ☽ °	'	☽'s Appt. Alt. °	'	☉'s ditto. °	'
2d Obſerv.	at	8	44½		88	13	44	42	43	15
			+ 20½							
					Suppl. of the contained ∠ =				29	27
Solar Time		9	05							
3d Obſerv.	at	9	00		88	9	41	42	46	11
Watch ſlow by this Obſ.			20	24						
The Mean, Watch ſlow			20	34	Suppl. of the contained ∠ =				30	00
4th Obſerv.	at	9	10		88	3	39	42	47	56
Watch ſlow by foregoing		+	20	34						
					Suppl. of the contained ∠ =				31	22
Solar Time		9	30	34						

The Weather being very cloudy obliged me to make the Obſervations as above, and by the Help of Two Aſſiſtants; and as they were made at Intervals of Time too great to take a Mean of the Times, I therefore computed them ſeparately (which ſhould always be done in like Caſes); then adding the Sum of the Reſults ariſing from the Obſervations, and dividing by the Number of Obſervations added, the Quotient will be the mean Reſult or Longitude by Obſervation, as in the Table, p. 11.

By what has been ſaid in the foregoing Rules, Remarks, &c. together with the Examples, I hope that no Difficulty will occur, in any Circumſtance that may or can happen, in the Method of making and computing the Obſervations reſpecting the Sun and Moon.

The following are Examples of the Moon and Stars.

In the Prince Henry Eaſt Indiaman, Capt. Haggis.

1761, March 18.

	per Watch. h	'	"	D. of the ☽ and Pol. °	'	☽'s Alt. up. Edge. °	'	✱'s Altitude. °	'
At	7	12	35	44	35	26	51	30	22
this comp.	7	28	20	44	42	28	29	30	15
	7	37	40	44	45½	29	52	30	2

The Star Pollux Weſt of the Moon.

	h	'	"	D. of the ☽ and Spica V. °	'	☽'s Alt. °	'	✱'s Alt. °	'
At	9	26	35	45	24½	42	45	37	16
At	9	32	10	45	21½	43	12	38	30
At	9	33	30	The Alt. of the ✱ for obtain. the Time				38	48
	9	38	50					40	00
At	9	46	50	45	17	44	16	41	40

Star (Spica) Eaſt of the Moon; and the Diſtance taken at the Weſtern Edge of the Moon.

Note, At 3h 36′ 32″ the true Alt. of the Sun was 26° 2′.

		h	′	″		°	′	
At		7	28	20	Lat. of the Ship at Noon	31	00	S.
Watch Slow	+		22	00	At 3 ½ P. M. made	0	7	S.
Appt Time		7	50	20	Lat. in at ☉'s Ob.	31	7	S.
Equa. of Ti.	+		8	1	Lat. in at Spica's	31	8	S.
Sum		7	58	21	is the mean or equal Time at the Ship.			
Aſſume		1	26	39	= 21° 39′ 45″ W. from Greenwich.			
Equal Time		9	25	0	at Greenwich.			

	°	′		°	′
Diſt. of W. Edge of ☽ and Pol.	44	42	Diſt. of ☽ and Spica	45	17
The half Diam. of the ☽ add		16,1	Half Diam. of ☽ ſub.		16,1
Appt. Center	44	58,1	Appt. Center	45	0,9

	s	°	′	″		s	°	′	″
1761 Lon. of Pollux	3	19	55	12	Lon. of Spica Vir.	6	20	30	35
Abberration add				4	Aberration add				18
Appt. Lon.	3	19	55	16		6	20	30	53
☽'s Ditto	5	4	47	50	☽'s Lon.	5	6	7	53
Diff. of Lon.		44	52	34	Diff. of Lon.		54	23	0

The Reſult of the Obſer. per Pollux = 1h 38′ 32″ = 24° 38′
ditto, per Spica = 1 37 43 = 24 26

	°	′
The half Sum is the true Difference of Lon. per Ob. W. from Greenwich	24	32
London to Greenwich, E. Subtract		5
Longitude of the Ship, from London, W.	24	27

REMARK I. The Concurrency of the Obſervations taken of Stars, Eaſt and Weſt of the Moon, ſelf-evidently proves the Determination of the obſerved Longitude of the Ship to be juſt. I have omitted the Computations, as not being material, ſince they may be readily done by the foregoing general Rules.

St.

St. Helena, June 14, 1761.

	h	′	″			°	′
At	7	24	20	P. M. appt. Ti. I ob. the D. of ☽ and Spica V.	=	33	39
Aſſume		23	40	= 5° 55′ W. from London	☽'s half Diam.		15,1
Sum =	7	48	0	the appt. Ti. at London.	Appt. D. of the Cen.	33	54,1

I. ☽'s Appt. Z. D. = 36° 03′,5 } per Calculation.
✱'s ditto = 7 7,9 } per Calculation.
Appt. D. of the Cen. 33 54,1

			Sum	77	5,5				
	38°	32′	45″	and	38	32	45		
—	36	3	30	and —	7	7	54		
Diff.	2	29	15	and	31	24	51		

s. co-ar. ☽'s Z. Diſt. = 0,2301734
s. co-ar. of ✱'s ditto = 0,9060536
s. of Diff. { 8,6375040
s. of Diff. { 9,7170216

19,4907526

s. of 33 48 22 = 9,7453763

Their Difference of Azimuths 67 36 44

☽'s Par. at 54° Alt. 31,6′
Refrⁿ 0,6

Difference 31,0

	s.	°	′	″
☽'s Longitude	7	23	49	30
✱'s Ditto	6	20	31	3
Difference of Longitude		33	18	27

The Moon Eaſt of the Star.

	°	′		°	′
From ☽'s Appt. Z. Diſt.	36	3,5	and to ✱'s Z. Diſt.	7	7,9
Take the Diff. of Par. and Refrⁿ		31,0	add Refr.		+,1
☽'s true Z. Diſt.	35	32,5	✱'s true Z. Diſt.	= 7	8,0

II.

	°	′	″	
II. To Tan. of the leſs true Z. Diſt.	7	8	00	= 9,0974219
Add the co-ſ. of the Diff. of Azi.	67	36	44	= 9,5807804
Log. Tan. of A.	2	43	42	= 8,6782023
The greater true Z. Diſt.	35	32	30	
Arc B.	32	48	48	
co-ſ. of A. co-ar.				0,0004927
co-ſ. of B.				9,9245070
co-ſ. leſs true Z. Diſt.				9,9966254
co-ſ. true Diſt. ob.	33	23	47	=9,9216251

Now we have given the three Sides of a ſpherical △ to find the ∠ at the Pole of the Ecliptic, it being the Difference of Longitude.

III. Given the *'s Lat. 2° 2′ 05″ S. and the ☽'s Lat. 33′ 50″ N. Hence the

* from the Pole	87	57	55	its s. co-ar. = 0,0002739
☽ from ditto	90	33	50	its s. co-ar. = 0,0000210
tr. Diſt. of ☽ & * ob.	33	23	47	s. of Diff. { = 9,4241257 = 9,4899241
Sum =	211	55	32	

105 57 46 and 105 57 46
—90 33 50 and —87 57 55

Diff. 15 23 56 and 17 59 51

18,9143447
s. of 16° 39′ 01½″ = 9,4571723
× 2

33 18 3 the Diff. of Lon. by Obſer.
33 18 27 { the Diff. of Lon. by Cal. from Aſtro. Tables.

0 0 24 the Cal. Lon. greater.

The Star Weſt of the Moon.

As the hourly Motion of the ☽ à * 30′,3 : 15° : : 24″ : 12′ the Proportional Quantity to be ſubtracted from the Lon. aſſumed, viz.

From 5° 55′ W.
Take — 12

Lon. by Obſer. 5 43 W.
Error of Lon. by Obſervation 11 Miles.

The

The Table following contains the variable Part of the Moon's Motion adapted to the firſt and laſt Columns, and to the Minutes of the Mean Second Differences at the Head of the Table; theſe variable Parts or Quantities are in Seconds and Decimal Parts, and to be applied as directed in the Notes thence following.

Hence by having given the Moon's Longitude, Latitude, or Declination from 24 to 24 Hours, by this Table of Second Differences the true Longitude, Latitude, or Declination may be found: but if the Longitude of the Moon be given from 12 to 12 Hours, then the true Longitude at any Hour or Minute may be more accurately obtained. Theſe tabulated to each Day at Noon, as in the Tables herein, are for January and February 1763; the Moon's Latitude, with the Longitude of the Moon at Mid-day and Mid-night for the Meridian of London; alſo their Firſt, Second, and Mean Second Differences, which I have done in order to make the Method of obtaining them more familiar to the Reader, and particularly to the Seafaring Gentlemen. I hope by what the following Pages contain, many ingenious Mariners will find their Latitude and Longitude by Obſervations of the Moon, which muſt give them the greateſt Pleaſure and Satisfaction, as they will reap very conſiderable Advantages thereby. If the Longitude of the Moon be found to any ſucceeding Hour to which it was before found, then the Difference will be the Moon's hourly Motion.

A Table of Second Differences from 1 to 16 Minutes, with the

24 H.		12 H.		1′	2′	3′	4′	5′	6′	7′	8′
h	′	h	′								
	12		6	0,246	0,5	0,75	1,0	1,25	1,5	1,7	2,0
	24		12	0,49	1,0	1,5	2,0	2,5	3,0	3,4	3,9
	36		18	0,73	1,5	2,2	2,9	3,7	4,4	5,1	5,8
	48		24	0,96	1,9	2,9	3,9	4,8	5,8	6,7	7,7
1			30	1,2	2,4	3,6	4,8	6,0	7,2	8,4	9,6
1	12		36	1,4	2,8	4,3	5,7	7,1	8,5	9,9	11,4
1	24		42	1,6	3,3	4,9	6,6	8,2	9,9	11,5	13,2
1	36		48	1,8	3,7	5,6	7,4	9,3	11,2	13,0	14,9
1	38		54	2,1	4,2	6,2	8,3	10,4	12,5	14,6	16,6
2		1		2,3	4,6	6,9	9,2	11,5	13,7	16,0	18,3
2	12	1	6	2,5	5,0	7,5	10,0	12,5	15,0	27,5	20,0
2	24	1	12	2,7	5,4	8,1	10,8	13,5	16,2	18,9	21,6
2	36	1	18	2,9	5,8	8,7	11,6	14,5	17,4	20,3	23,2
2	48	1	24	3,1	6,[illegible]	9,3	12,4	15,5	18,5	21,6	24,7
3		1	30	3,3	6,6	9,8	13,1	16,4	19,7	23,0	26,2
3	12	1	36	3,5	6,9	10,4	13,9	17,4	20,8	24,3	27,8
3	24	1	42	3,6	7,3	10,9	14,6	18,3	21,9	25,5	29,2
3	36	1	48	3,8	7,6	11,4	15,3	19,1	22,9	26,7	30,6
3	48	1	54	4,0	8,0	12,0	16,0	20,0	24,0	28,0	32,0
4		2		4,2	8,3	12,5	16,7	20,8	25,0	29,2	33,4
4	20	2	10	4,4	8,9	13,3	17,8	22,2	26,6	31,1	35,5
4	40	2	20	4,7	9,4	14,1	18,8	23,5	28,2	32,9	37,6
5		2	30	4,9	9,9	14,8	19,8	24,7	29,7	34,6	39,6
5	20	2	40	5,2	10,4	15,5	20,7	25,9	31,1	36,3	41,5
5	40	2	50	5,4	10,8	16,2	21,6	27,0	32,5	37,9	43,3
6		3		5,6	11,3	16,9	22,5	28,1	33,8	39,4	45,0
6	30	3	15	5,9	11,8	17,8	23,7	29,6	35,5	41,5	47,4
7		3	30	6,2	12,4	18,6	24,8	31,0	37,2	43,4	49,6
7	30	3	45	6,4	12,9	19,3	25,8	32,2	38,7	45,1	51,6
8		4		6,7	13,3	20,0	26,7	33,3	40,0	46,7	53,4
8	30	4	15	6,9	13,7	20,6	27,4	34,3	41,2	48,0	54,9
9		4	30	7,0	14,0	21,1	28,1	35,2	42,2	49,2	56,2
9	30	4	45	7;2	14,3	21,5	28,7	35,8	43,0	50,2	57,4
10		5		7,3	14,6	21,9	29,2	36,4	43,7	51,0	58,3
11		5	30	7,4	14,9	22,3	29,8	37,2	44,7	52,1	59,6
12		6		7,5	15,0	22,5	30,0	37,5	45,0	52,5	60,0

variable Quantity for the Time in the firſt and laſt Columns.

9′	10′	11′	12′	13′	14′	15′	16′	H. 12 ′	H. 2 ′
2,2	2,5	2,7	3,0	3,2	3,4	3,7	3,9	11 54	23 48
4,4	4,9	5,4	5,9	6,4	6,8	7,4	7,0	11 48	23 36
6,6	7,3	8,0	8,7	9,4	10,2	10,9	11,7	11 42	23 24
8,7	9,7	10,6	11,6	12,6	13,5	14,5	15,4	11 36	23 12
10,8	12,0	13,2	14,4	15,6	16,8	18,0	19,2	11 30	23 0
12,8	14,2	15,6	17,0	18,4	19,9	21,3	22,7	11 24	22 48
14,8	16,5	18,1	19,7	21,3	23,1	24,7	26,4	11 18	22 36
16,7	18,6	20,5	22,4	24,3	26,0	27,9	29,7	11 12	22 24
18,7	20,8	22,9	25,0	27,1	29,1	31,2	33,3	11 6	22 12
20,6	22,9	25,2	27,5	29,8	32,0	34,3	36,6	11 0	22 0
22,5	25,0	27,5	30,0	32,5	35,0	37,5	40,0	10 54	21 48
24,3	27,0	29,7	32,4	35,1	37,8	40,5	43,2	10 48	21 36
26,1	29,0	31,9	34,8	37,7	40,6	43,5	46,4	10 42	21 24
27,8	30,9	34,0	37,1	40,2	43,3	46,4	49,4	10 36	21 12
29,5	32,8	36,1	39,4	42,7	45,9	49,2	52,5	10 30	21 0
31,2	34,7	38,2	41,7	45,2	48,6	52,1	55,5	10 24	20 48
32,9	36,5	40,1	43,7	47,4	51,1	54,7	58,4	10 18	20 36
34,4	38,2	42,0	45,8	49,6	53,5	57,3	61,1	10 12	20 24
36,0	40,0	44,0	48,0	52,0	56,0	60,0	64,0	10 6	20 12
37,5	41,7	45,9	50,1	54,3	58,3	62,5	66,7	10 0	20 0
40,0	44,4	48,8	53,2	57,6	62,2	66,6	71,0	9 50	19 40
42,3	47,0	51,7	56,4	61,1	65,8	70,5	75,2	9 40	19 20
44,6	49,5	54,4	59,4	64,4	69,3	74,3	79,2	9 30	19 0
46,7	51,8	57,0	62,2	67,4	72,6	77,8	82,9	9 20	18 40
48,7	54,1	59,5	64,9	70,3	75,7	81,1	86,5	9 10	18 20
50,6	56,2	61,8	67,4	73,0	78,7	84,3	90,0	9 0	18 0
53,3	59,2	65,1	71,0	76,9	82,9	88,8	94,8	8 45	17 30
55,8	62,0	68,2	74,4	80,6	86,8	93,0	99,2	8 30	17 0
58,0	64,4	70,9	77,3	83,8	90,2	96,[illegible]	103,1	8 15	16 30
60,0	66,7	73,4	80,0	86,6	93,4	100,0	106,7	8 0	16 0
61,7	68,6	75,5	82,3	89,1	96,0	102,8	109,8	7 45	15 30
63,3	70,3	77,3	84,3	91,3	98,4	105,4	112,5	7 30	15 0
64,5	71,7	78,9	86,1	93,3	100,4	107,6	114,7	7 15	14 30
65,6	72,9	80,2	87,5	94,8	102,1	109,4	116,6	7 0	14 0
67,0	74,5	82,0	89,4	96,8	104,3	111,7	119,2	6 30	13 0
67,5	75,0	82,5	90,0	97,5	105,0	112,5	120,0	6 0	12 0

A Table of ſecond Differences from 17 to 24 Minutes.

24 H.		12H.		17′	18′	19′	20′	21′	22′	23′	24′
h	′	h	′								
	12		6	4,2	4,4	4,6	4,9	5,1	5,4	5,6	5,9
	24		12	8,4	8,9	9,4	9,8	10,3	10,8	11,3	11,8
	36		18	12,4	13,1	13,8	14,6	15,3	16,0	16,7	17,4
	48		24	16,4	17,4	18,4	19,3	20,3	21,2	22,2	23,2
1	0		30	20,4	21,6	22,8	24,0	25,2	26,4	27,6	28,8
1	12		36	24,1	25,6	27,0	28,4	29,8	31,2	32,6	34,0
1	24		42	28,0	29,7	31,3	33,0	34,6	36,1	37,8	39,4
1	36		48	31,6	33,5	35,4	37,2	39,1	41,0	42,9	44,7
1	48		54	35,4	37,4	39,4	41,6	43,7	45,8	47,9	50,0
2	0	1	0	38,9	40,2	42,5	45,8	48,1	50,4	52,7	55,0
2	12	1	6	42,5	45,0	47,5	50,0	52,5	55,0	57,5	60,0
2	24	1	12	45,9	48,6	51,3	54,0	56,7	59,4	62,1	64,8
2	36	1	18	49,3	52,2	55,1	m 58,0	1 0,9	1 3,8	1 6,7	1 9,6
2	48	1	24	52,5	55,6	58,7	1 1,8	1 4,9	1 8,0	1 11,1	1 14,2
3	0	1	30	55,8	59,0	62,3	1 5,6	1 8,9	1 12,2	1 15,5	1 18,8
3	12	1	36	59,0	62,5	66,0	1 9,4	1 12,9	1 16,2	1 19,9	1 23,4
3	24	1	42	62,0	65,7	69,3	1 13,0	1 16,6	1 20,2	1 23,8	1 27,5
	6	1	48	64,9	68,8	72,6	1 16,4	1 20,2	1 24,0	1 27,8	1 31,6
3	48	1	54	68,0	72,0	76,0	1 20,0	1 24,0	1 28,0	1 32,0	1 36,0
4	0	2	0	70,9	75,1	79,3	1 23,4	1 27,6	1 31,8	1 36,0	1 40,2
4	20	2	10	75,4	79,9	84,3	1 28,8	1 33,2	1 37,6	1 42,0	1 46,4
4	40	2	20	79,9	84,6	89,3	1 34,0	1 38,7	1 43,4	1 48,1	1 52,8
5	0	2	30	84,2	89,1	94,1	1 39,0	1 44,0	1 48,8	1 53,8	1 58,8
5	20	2	40	88,1	93,3	98,5	1 43,6	1 48,8	1 54,0	1 59,2	2 4,4
5	40	2	50	91,9	97,4	102,8	1 48,2	1 53,6	1 59,0	2 4,4	2 9,8
6	0	3	0	95,6	101,2	106,8	1 52,4	1 58,0	2 3,6	2 9,2	2 14,8
6	30	3	15	100,7	106,6	112,5	1 58,4	2 4,3	2 10,2	2 16,1	2 22,0
7	0	3	30	105,4	111,6	117,8	2 4,0	2 10,2	2 16,4	2 22,6	2 28,8
7	30	3	45	109,5	116,0	122,4	2 8,9	2 15,3	2 21,7	2 28,2	2 34,6
8	0	4	0	113,3	120,1	126,7	2 13,4	2 20,0	2 26,7	2 33,4	2 40,0
8	30	4	15	116,6	123,5	130,3	2 17,2	2 24,0	2 31,0	2 37,8	2 44,6
9	0	4	30	119,5	126,5	133,5	2 20,6	2 27,6	2 34,6	2 41,6	2 48,6
9	30	4	45	121,9	129,1	136,3	2 23,4	2 30,6	2 37,8	2 45,0	2 52,2
10	0	5	0	123,9	131,2	138,5	2 25,8	2 33,1	2 40,4	2 47,7	2 55,0
11	0	5	30	126,6	134,1	141,5	2 29,0	2 36,4	2 44,0	2 51,4	2 58,8
12	0	6	0	127,5	135,0	142,5	2 30,0	2 37,5	2 45,0	2 52,5	3 0,0

and from 24 to 30 Minutes incluſive.

						12 H.		24 H.	
25′	26′	27′	28′	29′	30′	h	′	h	′
6,2	6,4	6,7	6,9	7,2	7,4	11	54	23	48
12,3	12,8	13,3	13,8	14,3	14,7	11	48	23	36
18,2	19,0	19,7	20,4	21,2	21,9	11	42	23	24
24,1	25,1	26,0	27,0	28,0	29,0	11	36	23	12
30,0	31,2	32,4	33,6	34,7	35,9	11	30	23	
35,4	36,8	38,3	39,8	41,3	42,7	11	24	22	48
41,0	42,6	44,6	46,2	47,8	49,4	11	18	22	36
46,6	48,5	50,3	52,2	54,1	56,0	11	12	22	24
52,1	54,2	56,2	58,2	60,3	62,4	11	6	22	12
57,3	59,6	61,8	64,0	66,4	68,7	11		22	
62,5	65,0	67,5	70,0	72,4	74,9	10	54	21	48
67,5	70,2	72,9	75,6	78,3	81,0	10	48	20	35
72,5	75,4	78,3	81,2	84,0	86,9	1	42	21	24
77,3	80,4	83,4	86,6	89,6	92,7	10	66	21	12
82,1	85,4	88,6	91,8	95,1	98,4	10	30	21	
86,9	90,4	93,7	97,2	100,5	104,0	10	24	20	48
1 31,2	1 34,8	1 38,5	1 42,1	1 45,8	1 49,4	10	18	20	36
1 35,4	1 39,2	1 43,1	1 47,0	1 50,9	1 54,7	10	12	20	24
1 40,0	1 44,0	1 48,0	1 52,0	1 55,9	1 59,9	10	6	20	12
1 44,4	1 48,5	1 52,6	1 56,8	2 0,8	2 5,0	10		20	
1 50,8	1 55,4	1 59,8	2 4,3	2 8,7	2 13,1	9	50	19	40
1 57,5	2 2,2	2 6,9	2 11,6	2 16,3	2 21,0	9	40	19	20
2 3,8	2 8,8	2 13,7	2 18,6	2 23,5	2 28,4	9	30	19	
2 9,6	2 14,8	2 20,0	2 25,2	2 30,3	2 35,5	9	20	18	40
2 15,2	2 20,6	2 26,2	2 31,4	2 36,9	2 42,3	9	10	18	20
2 20,4	2 26,1	2 31,8	2 37,4	2 43,1	2 48,7	9		18	
2 27,9	2 33,8	2 39,8	2 45,8	2 51,8	2 57,7	8	45	17	30
2 35,0	2 41,2	2 47,4	2 53,6	2 59,7	3 5,9	8	30	17	
2 41,1	2 47,6	2 54,0	3 0,4	3 6,9	3 13,3	8	15	16	30
2 46,6	2 53,3	3 0,0	3 6,7	3 13,3	3 20,0	8		16	
2 51,6	2 58,4	3 5,3	3 12,1	3 18,9	3 25,8	7	45	15	30
2 55,6	3 2,8	3 9,8	3 16,8	3 23,9	3 30,9	7	30	15	
2 59,4	3 6,4	3 13,6	3 20,8	3 28,0	3 35,2	7	15	14	30
3 2,3	3 9,5	3 16,8	3 24,1	3 31,5	3 38,8	7		14	
3 ,2	3 13,6	3 21,1	3 28,5	3 36,0	3 43,4	6	30	13	
3 7,5	3 15,0	3 22,5	3 30,0	3 38,5	3 45,0	6		12	

Notes to be obſerved in the Uſe of the foregoing Table.

Note 1. If the Firſt Differences (of Longitudes, Latitudes, Declinations, or Right Aſcenſions) increaſe, then ſubtract the variable Quantity, per Table above; but if the Firſt Differences decreaſe, then add the variable Quantity to the Mean Increaſe of the Longitude, &c. for the Time given.

2. To find the Mean of the Second Differences of Longitudes; when the Signs are alike, that is, when the Differences of the Firſt Differences are all increaſing or decreaſing, then the Second Differences will have like Signs, otherwiſe unlike Signs. And when the Firſt Differences are increaſing, then the Second Differences are marked with the Sign +; but if the Firſt Differences decreaſe, then the Second Differences are marked with the Sign —, as + 5, — 3 = 2. Alſo if the

Second Differences were	+ 3′ 17″	− 1′ 10″	Difference.
and	— 4 27	0 35	½ ditto the Mean.

Suppoſe the 2d Differences	+ 10′ 12″	If 2d Differences were	— 27′ 40″
and	— 3 50	and	— 13 17
Difference	+ 6 22	the Sum	40 57
Enter the foregoing Tab. with	3 11	Enter the Table with	20 28 the ½

3. If the Mean Second Difference be greater than 30′, as per Table, then divide it by any Number, and take out the variable Quantity, which multiply by the ſaid Number for the Reſult.

4. If the Mean Second Difference be leſs than 1′, then take out for Seconds as if it were Minutes, and divide the Produce by 60, the Quot. will be the true Reſult.

EXAMPLE

EXAMPLE I.

To find the true Longitude of the Moon the 1ſt of January, 1763. at 12ʰ P. M, at the Meridian of Paris.

1762	☽'s true Longitude.	1ſt Diff.	2d Diff.
Dec. 31.	s. ° ′ ″		
	= 3 16 21 22	° ′ ″	
1763		14 37 59	′ ″
Jan. 1	= 4 00 59 01		+ 5 4
		14 43 03	
2	= 4 15 42 04		− 2 9
		14 40 54	
3	= 5 00 22 58		

The Sum = + 2 55

The ½ Sum = 1 27 the Mean to enter the Table.

h ° ′ ″

Now if 24 gives 14 43 03 the Increaſe of Lon.

12 ditto 7 21 31,5 for the Mean Increaſe, and

againſt 12ʰ under 1′ is 7″,5

and under 2 is 15,0

The Sum = 22,5

and half Sum for 1′ ½ 11,2 ſubtract, becauſe the Mean 2d Difference is + or more.

° ′ ″

Hence from 7 21 31,5

Subtract 11,2

s. ° ′ ″

and there will remain the true Incr. of Longitude in 12ʰ } 7 21 20, which added to 4 0 59 01

viz. + 7 21 20

The Sum is the true Lon. at 1 Day 12 Hours at Paris 4 8 20 21

EXAMPLE II.

Required the true Longitude of the Moon, at 18ʰ 30′ P. M. at Paris.

h ° ′ ″ h ′ ′′ ′

12 = 7 21 31,5 againſt 18 30 is 5,3 under 1

6 = 3 40 45,7 10,6 under 2

½ = 0 18 23,8

Half Sum is 8,0 the variable Quantity.

M. Incr. 11 21 41,0

V. Part − 8,

s. ° ′ ″

Hence to the Mid-day Lon. 4 00 59 01

true Incr. 11 20 33 + 11 20 23

The Sum is the true Lon. required = 4 12 19 34

Obſerve, that the Firſt Difference is adapted to the Middle Time of the two given Times; the Second Difference to the Middle Time of the three given Times; and the Mean Second Difference to the Middle Time of the four given Times, Hence the Mean Second Difference of the 1ſt, 2d, 3d, and 4th Days, is 2½ Days.

Note, That the Mean Second Difference of the 24^h Differences, being divided by 8, gives the variable Quantity for the 12^h Second Difference of Longitude, Declination, &c. Therefore when the Firſt Difference increaſes, ſubtract ⅛ of the Mean Second Difference. If the Firſt Difference decreaſes, then add ⅛ to or from the Mean 12 Hours Increaſe, and you will have the true Increaſe.

For the Declination of the Moon.

When the Mean Second Differences of Declinations are leſs than $8'$, no Regard need to be taken of them, ſince the Declination is only required to Minutes, and the greateſt variable Part or Quantity ariſing from the Mean Second Difference of $8'$ being only $1'$; therefore the variable Part for all other Times greater or leſs than twelve Hours will be leſs than $1'$.

If the Declinations be of different Names, then the Sum is the Firſt Difference. And, when the Signs of the Second Differences are alike (that is both +, or both —) then half of the two Second Differences, is the Mean Second Difference. But when the Signs are unlike (that is one +, and the other —) then half their Difference is the Mean Second Difference, as per Example foregoing.

Required to find the Declination of the Moon the 22d of May, 1763, at 8½ P. M. the Time of her Southing, at the Meridian, 30° W. from London.

M. D.	Decl.	1ſt Diff.	2d Diff.	Mean 2d Diff.
	° ′	° ′		
		6 10	′	
21	8 37 N.		+ 32	
		6 42		20′
22	1 55		+ 08	
		6 50		3
23	4 55 S.		— 14	
		6 36		24
24	11 31		— 34	
		6 02		
25	17 33			

The Mean 2d Diff. 3′ gives 0′ for variable Quantity.

h ° ′
24 = 6 50 the Variation of Declination.

8 = 2 16⅔
1 = 0 17
½ = 0 8½

8½ = 2 25 the Variation of Declination
Decl. the 22d = 1 55 N. decreaſing

Remains the Decl. = 0 30 S.

To find the Declination the 23d at 9^h 11′ the Time of the ☽'s Southing, at the Meridian of London.

		°	′
Daily Variation	=	6	36
8^h	=	2	12
1	=	0	16 ½
11′	=	0	3
9^h 11′	=	2	31 ½
Mean 2d Difference 24′ gives variable Quantity	+		2 ⅝
True Va. of Declination	=	2	34 +
Declination the 23d		4	55 S.
The Sum is the true Declination	=	7	29 S.

Obſerve, in taking out the variable Quantity, that if you enter the Table with Degrees at the Head of the Table, then the variable Quantity will be Minutes, for Example:

Suppoſe the Mean Sec. Diff. to be 1° 29′ now under 1′ is 7′,5 againſt 12^h
and for 29′ add for the Increaſe 3,7

Hence the variable Quantity 11,2

Otherwiſe; Thus 1° 29′ = 89′, and ⅓ thereof is 30′—; now under 30′, and againſt 12^h is 3′¾, which multiplied by 3 give 11′ ¼ as before:

Or 89′, ¼ thereof, is 22′ ¼ under which is 2′ 47″
which multiply by the N° divided, by × 4

The variable Quantity 11 8

Obſerve, that the greateſt daily Variations of the Moon in Longitude, Latitude, and Declination are as follows, nearly.

	Lon.		Lat.		Decl.	
h	°	′	°	′	°	′
in 24	16		2	40	7	12
12	8		1	20	3	36
6	4		0	40	1	48
3	2		0	20	0	54
1	0	40	0	7	0	18

The greateſt Decl. of the Moon is 28° 46′ ″
And of the Sun 23 28 50

The Mean Inclination of the Moon's Orbit is about 5° 8′ 30″
The greateſt being 5 17 30
And the leaſt 4 59 30

The Ratio of the Par. to the Diamr. as 57′,7 to 15′

In like Manner the Declination, at any Time, may be found; only obſerving to deduct the variable Quantity, when the firſt Differences increaſe, and to add it when they decreaſe.

A Table of the Moon's Parallax of Altitude.

☽'s Ap. Alt.	The Moon's Horizontal Parallax.								
	54′	55′	56′	57′	58′	59′	60′	61′	61′½
1	54,0	55,0	56,0	57,0	58,0	59,0	60,0	61,0	61,5
2	54,0	55,0	56,0	57,0	58,0	59,0	60,0	61,0	61,5
3	53,9	54,9	55,9	56,9	57,9	58,9	59,9	60,9	61,4
4	53,9	54,8	55,8	56,8	57,8	58,9	59,9	60,9	61,4
5	53,8	54,8	55,8	56,8	57,8	58,8	59,8	60,8	61,3
6	53,7	54,7	55,7	56,7	57,7	58,7	59,7	60,7	61,2
7	53,6	54,6	55,6	56,6	57,6	58,6	59,6	60,6	61,1
8	53,5	54,5	55,5	56,4	57,4	58,5	59,5	60,4	60,9
9	53,3	54,3	55,3	56,3	57,3	58,3	59,3	60,3	60,8
10	53,2	54,1	55,1	56,1	57,1	58,1	59,1	60,1	60,6
11	53,0	54,0	55,0	56,0	56,9	57,9	58,9	59,9	60,4
12	52,8	53,8	54,8	55,8	56,7	57,7	58,7	59,7	60,2
13	52,6	53,6	54,6	55,5	56,5	57,5	58,5	59,4	59,9
14	52,4	53,4	54,3	55,3	56,3	57,2	58,2	59,2	59,7
15	52,2	53,1	54,1	55,0	56,0	57,0	58,0	58,9	59,4
16	51,9	52,9	53,8	54,8	55,8	56,7	57,7	58,5	59,0
17	51,7	52,6	53,6	54,5	55,5	56,4	57,4	58,3	58,8
18	51,4	52,3	53,3	54,2	55,2	56,1	57,1	58,0	58,5
19	51,1	52,0	53,0	53,9	54,8	55,8	56,7	57,7	58,2
20	50,8	51,7	52,6	53,6	54,5	55,5	56,4	57,3	57,8
21	50,4	51,4	52,2	53,2	54,1	55,1	56,0	56,9	57,4
22	50,1	51,0	51,9	52,7	53,8	54,7	55,6	56,5	57,1
23	49,7	50,6	51,5	52,3	53,4	54,3	55,2	56,1	56,6
24	49,3	50,2	51,1	52,1	53,0	53,9	54,8	55,7	56,2
25	48,9	49,8	50,7	51,7	52,6	53,5	54,4	55,3	55,7
26	48,5	49,4	50,3	51,2	52,1	53,0	53,9	54,8	55,2
27	48,1	49,0	49,9	50,8	51,7	52,6	53,5	54,3	54,8
28	47,7	48,6	49,4	50,3	51,2	52,1	53,0	53,8	54,3
29	47,2	48,1	49,0	49,9	50,7	51,6	52,5	53,3	53,8
30	46,8	47,6	48,5	49,4	50,2	51,1	52,0	52,8	53,3
31	46,3	47,1	48,0	48,9	49,7	50,6	51,4	52,3	52,7
32	45,8	46,6	47,5	48,3	49,2	50,0	50,9	51,7	52,0
33	45,3	46,1	47,0	47,8	48,6	49,5	50,3	51,1	51,5
34	44,8	45,6	46,4	47,3	48,1	48,9	49,7	50,7	51,1
35	44,2	45,1	45,9	46,7	47,5	48,3	49,1	50,0	50,4
36	43,7	44,5	45,3	46,1	46,9	47,7	48,5	49,3	49,7
37	43,1	43,9	44,7	45,5	46,3	47,1	47,9	48,7	49,1
38	42,6	43,3	44,1	44,9	45,7	46,5	47,3	48,1	48,5
39	42,0	42,7	43,5	44,3	45,1	45,9	46,6	47,4	47,8
40	41,4	42,1	42,9	43,7	44,4	45,2	46,0	46,7	47,1
41	40,8	41,5	42,3	43,0	43,8	44,5	45,3	46,0	46,4
42	40,1	40,9	41,6	42,4	43,1	43,9	44,6	45,3	45,7
43	39,5	40,2	41,0	41,7	42,4	43,9	43,9	44,6	45,0
44	38,8	39,6	40,3	41,0	41,7	42,4	43,2	43,9	44,3
45	38,2	38,9	39,6	40,3	41,0	41,7	42,6	43,1	43,5

☽'s Ap. Alt.	The Moon's Horizontal Parallax continued.								
	54′	55′	56′	57′	58′	59′	60′	61′	61′½
46	37,5	38,2	38,9	39,6	40,3	41,0	41,7	42,4	42,7
47	36,8	37,7	38,2	38,9	39,6	40,2	40,9	41,6	41,9
48	36,1	36,8	37,5	38,1	38,8	39,5	40,1	40,8	41,1
49	35,4	36,1	36,7	37,4	38,1	38,7	39,4	40,0	40,3
50	34,7	35,4	36,0	36,6	37,3	37,9	38,6	39,2	39,5
51	34,0	34,6	35,2	35,9	36,5	37,1	37,8	38,4	38,7
52	33,3	33,9	34,5	35,1	35,7	36,3	36,9	37,6	38,0
53	32,5	33,1	33,7	34,3	34,9	35,5	36,1	36,7	37,1
54	31,7	32,3	32,9	33,5	34,1	34,7	35,3	35,9	36,2
55	31,0	31,5	32,1	32,7	33,3	33,8	34,4	35,0	35,3
56	30,2	30,7	31,3	31,9	32,4	33,0	33,6	34,1	34,4
57	29,4	29,9	30,5	31,0	31,6	32,1	32,7	33,2	33,5
58	28,6	29,1	29,7	30,2	30,7	31,3	31,8	32,3	32,6
59	27,8	28,3	28,8	29,4	29,9	30,4	30,9	31,4	31,7
60	27,0	27,5	28,0	28,5	29,0	29,5	30,0	30,5	30,8
61	26,2	26,7	27,1	27,6	28,1	28,6	29,1	29,6	29,9
62	25,4	25,8	26,3	26,8	27,2	27,7	28,2	28,6	28,9
63	24,5	25,0	25,4	25,9	26,3	26,8	27,2	27,7	28,0
64	23,7	24,1	24,5	25,0	25,4	25,9	26,3	26,7	27,0
65	22,8	23,2	23,7	24,1	24,5	25,0	25,4	25,8	26,1
66	22,0	22,4	22,8	23,2	23,6	24,0	24,4	24,8	25,1
67	21,1	21,5	21,9	22,3	22,7	23,0	23,4	23,8	24,1
68	20,2	20,6	21,0	21,4	21,7	22,1	22,5	22,9	23,2
69	19,4	19,7	20,1	20,4	20,8	21,1	21,5	21,9	22,2
70	18,5	18,8	19,1	19,5	19,8	20,2	20,5	20,9	21,2
71	17,6	17,9	18,2	18,6	18,9	19,2	19,5	19,8	20,0
72	16,7	17,0	17,3	17,6	17,9	18,2	18,5	18,8	19,0
73	15,8	16,1	16,4	16,7	17,0	17,2	17,5	17,8	18,0
74	14,9	15,1	15,5	15,7	16,0	16,3	16,5	16,8	17,0
75	14,0	14,2	14,5	14,8	15,0	15,3	15,5	15,8	16,0
76	13,1	13,3	13,6	13,8	14,0	14,3	14,5	14,8	14,9
77	12,1	12,4	12,6	12,8	13,0	13,3	13,5	13,7	13,9
78	11,2	11,4	11,6	11,9	12,0	12,3	12,5	12,7	12,8
79	10,3	10,5	10,7	10,9	11,1	11,3	11,5	11,7	11,8
80	9,4	9,6	9,7	9,9	10,1	10,2	10,4	10,6	10,7
81	8,5	8,6	8,8	8,9	9,0	9,2	9,4	9,6	9,7
82	7,5	7,7	7,8	7,9	8,0	8,2	8,4	8,5	8,6
83	6,6	6,7	6,8	6,9	7,0	7,2	7,3	7,5	7,6
84	5,6	5,8	5,9	6,0	6,1	6,2	6,3	6,4	6,5
85	4,7	4,8	4,9	5,0	5,1	5,2	5,3	5,3	5,4
86	3,8	3,9	3,9	4,0	4,0	4,1	4,2	4,3	4,4
87	2,8	2,9	3,0	3,0	3,0	3,1	3,2	3,3	3,4
88	1,9	1,9	2,0	2,0	2,0	2,1	2,1	2,2	2,3
89	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,1	2,0
90	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

The Uſe of the foregoing Table.

Enter the Table with the Moon's Horizontal Parallax at the Head; viz. 54′, 55′, &c. to 61′ ½; and under the preſent Horizontal Parallax, and againſt the Degrees of the Moon's Altitude, in the Left-hand Column, is the Moon's Parallax at that Altitude.

EXAMPLE.

Required to find the Moon's Parallax, at 17° 30′ apparent Altitude, when the
Moon's preſent Horizon. Parallax is 57′
under 57′ and againſt 17° is Parallax 54,5
and againſt 18° is ditto 54,2
Therefore at 17° ½ Altitude is 54′,35, the Parallax required.

Required to find the true Altitude of the Moon, the 29th of January, 1763, at 34′ after Midnight (the Time of her Southing); ſuppoſing her Meridian Altitude obſerved to be 20° 40′, the Dip of the Horizon, and ½ Diameter allowed for.

By the following Table I find the Horizon. Parallax to be 60′ 59″ at the Meridian of London, when the Moon is South. Now by the foregoing Table againſt 21° Altitude, and under 61′ Horizon. Parallax, is 56′,9 the Parallax of the Alt.
from which take the Refraction 2,5

Difference 54,4

Now to the apparent Altitude obſerved 20° 40′
Add the Difference above found 54 ½

The Sum is the true Altitude of the Moon = 21 34 ½

A Table

A Table of the Apparent Increaſe of the Moon's Diam. at different Degrees of Height.

☽'s Ap. Alt.	The Moon's Horizontal Diameter.					
	29′½	30′	31′	32′	33′	34′
2	1,0	1,0	1,0	1,1	1,2	1,2
4	2,0	2,0	2,1	2,3	2,4	2,6
6	2,9	2,9	3,2	3,5	3,6	4,0
8	3,9	3,9	4,3	4,7	4,8	5,3
10	4,8	5,1	5,4	5,8	6,1	6,5
12	5,8	6,1	6,5	6,9	7,3	7,8
14	6,8	7,1	7,5	8,1	8,5	9,1
16	7,7	8,0	8,5	9,1	9,7	10,4
18	8,7	9,0	9,6	10,3	10,9	11,7
20	9,6	10,1	10,7	11,4	12,1	12,9
22	10,6	11,0	11,7	12,5	13,3	14,1
24	11,5	11,9	12,7	13,6	14,4	15,3
26	12,4	12,9	13,7	14,6	15,5	16,5
28	13,3	13,8	14,7	15,6	16,6	17,6
30	14,1	14,6	15,6	16,6	17,6	18,7
32	14,9	15,5	16,5	17,6	18,7	19,8
34	15,8	16,2	17,4	18,5	19,7	20,9
36	16,5	17,1	18,3	19,5	20,7	22,0
38	17,3	17,9	19,1	20,4	21,7	23,0
40	18,1	18,7	20,0	21,3	22,6	24,1
42	18,8	19,4	20,8	22,2	23,6	25,0
44	19,6	20,2	21,6	23,0	24,5	26,0
46	20,3	20,9	22,4	23,8	25,3	26,9
48	21,0	21,6	23,1	24,6	26,2	27,8
50	21,5	22,3	23,8	25,4	27,0	28,7
52	22,1	22,9	24,5	26,1	27,7	29,5
54	22,7	23,6	25,1	26,8	28,4	30,3
56	23,3	24,1	25,8	27,4	29,2	31,0
58	23,8	24,7	26,4	28,1	29,9	31,7
60	24,4	25,2	27,0	28,7	30,5	32,4
62	24,9	25,7	27,6	29,3	31,2	33,1
64	25,5	26,2	28,2	29,9	31,9	33,8
66	26,0	26,7	28,6	30,5	32,4	34,3
68	26,4	27,3	29,0	30,9	32,8	34,8
70	26,7	27,9	29,3	31,2	33,2	35,3
72	27,0	28,3	29,6	31,5	33,5	35,7
74	27,3	28,6	29,9	31,8	33,8	36,0
76	27,5	28,8	30,2	32,0	34,0	36,2

To find the Latitude of a Ship (or Place) by obſerving the Meridian Altitude of the Moon.

1. Bring down to the Horizon the round Edge, or enlightened Limb of the Moon (with a Hadley's Quadrant) then if it be the lower Edge, add the Difference between the Dip of the Horizon, and half the Moon's Diameter to the Altitude taken, and the Sum will be the apparent Altitude of the Center of the Moon; but if the upper Edge of the Moon be taken in the Horizon, ſubtract the Sum of the half Diameter and Dip, the Remainder is the apparent Altitude of the Center of the Moon by Obſervation.

2. To reduce the apparent Altitude to the true Altitude, enter the Table of the Moon's Parallax of Altitude, with the apparent Altitude in the firſt Column, and under the preſent Horizontal Parallax (as obtained from the ~~foregoing or~~ following Tables~~, for the Years 1763 and 1764~~) and take out the Parallax of the preſent Altitude, then from the Parallax of Altitude take the Refraction, and add the Difference to the apparent Altitude, the Sum will be the true Altitude of the Moon on the Meridian, whoſe comp. to 90 Degrees is the true Zenith Diſtance.

3. Take out from the following Tables the Declination of the Moon, and then obſerve if the Zenith Diſtance, and the Declination be the ſame (that is, both North or South) and if ſo, and the Zenith Diſtance the greater, then ſubtract the Declination from the Zenith Diſtance, and the Remainder is the Latitude, and of a contrary Name to the Declination.

4. If the Zenith Diſtance, and the Declination be of the ſame Name, and the Declination the greater, then from the Declination take the Zenith Diſtance, and the Remainder is the Latitude, and of the ſame Name as the Declination.

5. If the Zenith Diſtance be of a contrary Name, then the Sum of the Zenith Diſtance and Declination is the Latitude, and of the ſame Name as the Declination.

6. If the Zenith Diſtance and Declination be equal, then if they are of the ſame Name, the Ship or Place is ſituated under the Equinoctial, and has no Latitude.

But if the Zenith Diſtance and the Declination are of different Names, then the Sum is the Latitude, and of the ſame Name with the Declination,

A new

A new Table of Refractions, adapted to the middle State of the Air.

Ap.Alt.	Refract.	Ap.Alt.	Refract.	Ap.Alt.	Refract.	Ap.Alt.	Refrac
° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″
0 0	33 0,0	6 50	7 30,2	19 30	2 39,4	62 0	0 30,4
5	32 10,4	7 0	7 20,5	20 0	2 35,1	63	29,1
10	31 22,2	7 10	7 11,1	20 30	2 31,0	64	27,8
15	30 35,4	7 10	7 2,1	21 0	2 27,2	65	26,5
20	29 49,7	7 30	6 53,4	21 30	2 23,6	66	25,3
30	28 22,3	7 40	6 45,1	22 0	2 20,3	67	24,1
32	28 4,8	7 50	6 37,1	23	2 13,7	68	22,9
36	27 30,3	8 0	6 29,4	24	2 7,4	69	21,7
40	26 59,7	8 10	6 22,0	25	2 1,6	70	20,6
50	25 41,8	8 20	6 14,8	26	1 56,2	71	19,5
1 0	24 28,6	8 30	6 8,0	27	1 51,2	72	18,4
1 10	23 19,8	8 40	6 1,3	28	1 46,6	73	17,3
1 20	22 15,2	8 50	5 54,8	29	1 42,4	74	16,2
1 30	21 14,7	9 0	5 48,5	30	1 38,4	75	15,1
1 40	20 17,9	9 10	5 42,4	31	1 34,6	76	14,0
1 50	19 24,8	9 20	5 36,5	32	1 31,0	77	13,0
2 0	18 35,0	9 30	5 30,9	33	1 27,6	78	12,0
2 10	17 48,4	9 40	5 25,4	34	1 24,4	79	11,0
2 20	17 4,5	9 50	5 20,0	35	1 21,4	80	10,0
2 30	16 23,8	10 0	5 14,8	36	1 18,5	81	9,0
2 40	15 45,4	10 15	5 7,3	37	1 15,7	82	8,0
2 50	15 9,4	10 30	5 0,1	38	1 13,0	83	7,0
3 0	14 35,6	10 45	4 53,2	39	1 10,4	84	6,0
3 10	14 3,9	11 0	4 46,6	40	1 7,9	85	5,0
3 20	13 34,1	11 15	4 40,3	41	1 5,5	86	4,0
3 30	13 6,2	11 30	4 34,3	42	1 3,3	87	3,0
3 40	12 39,6	11 45	4 28,6	43	1 1,1	88	2,0
3 50	12 14,6	12 0	4 23,2	44	59,0	89	1,0
4 0	11 51,1	12 20	4 16,1	45	57,0	90	0,0
4 10	11 28,9	12 40	4 9,4	46	55,0	Height of Eye.	Ap Dip of Hor.
4 20	11 7,9	13 0	4 3,0	47	53,1		
4 30	10 48,0	13 20	3 56,9	48	51,2	Feet.	Min.
4 40	10 29,2	13 40	3 51,1	49	49,4	4	1,9
4 50	10 11,3	14 0	3 45,5	50	47,6	6	2,3
5 0	9 54,3	14 20	3 40,1	51	45,9	8	2,7
5 10	9 38,2	14 40	3 34,9	52	44,2	10	3,0
5 20	9 22,8	15 0	3 29,9	53	42,6	12	3,3
5 30	9 8,0	15 30	3 23,7	54	41,1	14	3,6
5 40	8 54,0	16 0	3 16,9	55	39,6	16	3,9
5 50	8 40,6	16 30	3 10,5	56	38,2	18	4,1
6 0	8 27,8	17 0	3 4,5	57	36,8	20	4,3
6 10	8 14,9	17 30	2 58,9	58	35,5	24	4,7
6 20	8 2,8	18 0	2 53,6	59	34,2	28	5,0
6 30	7 51,1	18 30	2 48,6	60	33,0	34	5,5
6 40	7 40,3	19 0	2 43,9	61	31,7	40	6,0

The Uſe of the foregoing Table.

Subtract the Refraction from the apparent Altitude of the Center of the Sun, Moon, or Stars; or add it to the apparent Zenith Diſtance, and the Reſult will be the true Altitude, or Zenith Diſtance obſerved.

Subtract the apparent Dip of the Horizon from the apparent Altitude. If the Decimal Part of the Dip exceeds ,5 you may take 1′ for it.

A Table of the Sun's true Longitude, &c. with the Equation of Time.

1763 Jan.	☉'s tr. Long. at tr. Noon.				½ Diurn. Incr. of Longit.		Hourly Incr.		Diam.		Equ. of Time, ☉ ſlow.		Dail. Diff.
	s	°	′	″	′	″	′	″	′	″	′ +	″	″
24	10	4	21	15	30	29,5	2	32,46	32	35	12	37	14
25		5	22	13	30	29,	2	32,4		35	12	51	13
26		6	23	11	30	28,	2	32,34		34	13	4	12
27		7	24	7	30	27,5	2	32,3		34	13	16	12
28		8	25	2	30	27,	2	32,25		34	13	28	11
29		9	25	57	30	26,5	2	32,2		34	13	39	10
30		10	26	50	30	26,	2	32,2		34	13	49	9
31		11	27	42						34	13	58	

1763	Place of ☽'s Node. Daily Diff. 3′⅓.		
	s	°	′
Jan. 28	0	27	19
Feb. 6	0	26	49
15	0	26	19
24	0	25	49½

Hence the Pla.
or Long. of the
Node may be
known at any
time to 1 Min.

A Table

A Table of the Moon's true Longit. at Apparent Noon and Midnight, Hourly Motion, Parallax, Diameter, &c. with the Latitude each Day at Noon.

1763 Jan.	☽'s tr. Lon. at tr. Noon.	12 H. Incr. or 1ſt Diff.	2d Diff.	Mean 2d Diff.	Hourly Motion.	Latitude North.	1ſt Diff.	2d Diff.	Parall. Horiz.	Diam. Horizo.	1763 Jan.
days.	s ° ′ ″	° ′ ″	′ ″	′ ″	′ ″	° ′ ″	′ ″	′ ″	′ ″	′ ″	days.
24	1 28 51 33	+ 6 33 4			32 45,3	2 37 49			56 56	31 3	24
24½	2 5 24 37	6 40 5	+7 1	7 14	33 20,4		54 48		57 23	31 18	24½
25	2 12 4 42	6 47 32	+7 27	7 26	33 57,7	3 32 37		— 10 8	57 50	32	25
25½	2 18 52 14	6 54 58	+7 26	7 26	34 34,8		44 40		58 19	48	25½
26	2 25 47 12	7 2 24	+7 26	7 10	35 22,0	4 17 17		— 14 6	58 47	32 3	26
26½	3 2 49 36	7 9 17	+6 53	6 38	35 46,4		30 34		58 12	18	26½
27	3 9 58 53	7 16 0	+6 43	6 11	36 20,0	4 47 51		— 17 40	59 37	30	27
27½	3 17 14 53	7 21 39	+5 39	5 19	36 48,2		12 54		59 58	42	27½
28	3 24 36 32	7 26 38	+4 59	4 18	37 23,2	5 0 45		— 5 46	60 20	32 54	28
28½	4 2 3 10	7 30 15	+3 37	3 5	37 31,2		7 8		60 36	33 3	28½
29	4 9 33 25	7 32 48	+2 33	1 51	37 44,0	4 53 37		+ 20 30	60 52	12	29
29½	4 17 6 13	7 33 57	+1 9	0 42	37 49,7		27 38		60 58	16	29½
30	4 24 40 10	— 7 33 43	—0 14	0 47	37 48,6	4 25 59		+ 18 38	61 5	19	30
30½	5 2 13 53	7 32 23	—1 20	1 59	37 41,9		46 16		61 3	18	30½
31	5 9 46 16	7 29 44	—2 39		37 29,8	3 59 43			61 1	17	31
31½	5 17 16 0										31½

A Table of the Moon's Longitude at mean Noon, Hourly Motion, &c.

1763 Feb.	☽'s tr. Long. at mean Noon.	12 H. Incre. or 1ſt Diff.	2d Diff.	Mean 2d Diff.	Hourly Motion.	Latitude.	1ſt Diff.	2d Diff.	Parall. Horiz.	Diam. Horiz.
days.	s ° ′ ″	° ′ ″	′ ″	′ ″	′ ″	° ′ ″	′ ″	′ ″	′ ″	′ ″
½	5 17 7 17	— 7 26 20								
1	5 24 33 37	7 21 50	—4 30	4 39	37 0,4	2 38 40 N			60 41	33 6
1½	6 1 55 27	7 17 2	4 48	5 15	36 37,2		70 38		60 24	32 57
2	6 9 12 29	7 11 35	5 27	5 28	36 11,5	1 28 2		+ 4 16	60 7	32 48
2½	6 16 24 4	7 6 7	5 28	5 40	35 44,3		74 54		59 47	32 42
3	6 23 30 11	7 0 14	5 53	5 42	35 15,8	0 13 8		— 1 22	59 27	32 25
3½	7 0 30 25	6 54 43	5 31	5 29	34 47,3		73 32		59 4	32 13
4	7 7 25 8	6 49 16	5 27	5 19	34 19,9	1 0 24 S		— 5 7	58 41	32 0
4½	7 14 14 24	6 44 5	5 11	5 9	33 53,3		68 25		58 17	31 48
5	7 20 58 29	6 38 58	5 7	4 54	33 27,7	2 8 49		— 8 38	57 54	31 35
5½	7 27 37 27	6 34 17	4 41	4 30	33 3,2		59 47		57 31	31 23
6	8 4 11 44	6 29 58	4 19	4 9	32 40,7	3 8 36		—11 7	57 8	31 10
6½	8 10 41 42	6 25 59	3 59	3 49	32 19,9		48 40		56 48	30 59
7	8 17 7 41	6 22 21	3 38	3 29	32 0,8	3 57 16		—12 44	56 29	30 48
7½	8 23 30 2	6 19 1	3 20	3 9	31 43,4		35 56		56 11	30 38
8	8 29 49 3	6 16 3	2 58	2 53	31 27,7	4 33 12		—13 44	55 52	30 29
8½	9 6 5 6	6 13 16	2 47	2 40	31 13,3		22 12		55 36	30 19
9	9 12 18 22	6 10 42	2 34	2 26	30 59,9	4 55 24		—14 6	55 20	30 11
9½	9 18 29 4	6 8 23	2 19	2 11	30 47,7		8 6		55 7	30 5
10	9 24 37 27	6 6 20	2 3	2 0	30 36,8	5 3 30		— 2 13	54 54	29 58
10½	10 0 43 47	6 4 22	1 58	1 54	30 26,8		5 53		54 44	29 53
11	10 6 48 9	6 2 33	1 49	1 45	30 17,3	4 57 37		+13 15	54 34	29 46
11½	10 12 50 42	6 0 52	1 41	1 32	30 13,5		19 8		54 26	29 42
12	10 18 51 34	5 59 20	1 32	1 28	30 0,5	4 38 29		+12 11	54 18	29 37
12½	10 24 50 54	5 57 55	1 25	1 22	29 53,2		31 19		54 12	29 34
13	11 0 48 49	5 56 35	1 20	1 12	29 46,2	4 7 10		+10 37	54 6	29 30

13½	11 6 45 24		−1 4		29 40,2		41 56		54 4	29 30
		− 5 55 31		0 59						
14	11 12 40 55		0 55		29 35,2	3 25 14		+ 8 46	54 2	29 28
		5 54 36		0 45						
14½	11 18 35 31		0 35		29 31,5		50 42		54 1	29 28
		5 54 1		0 23						
15	11 24 29 32		0 12		29 29,6	2 34 32		+ 6 42	54 1	29 28
		5 53 49		0 12						
15½	0 0 23 21		0 11	0 12	29 28,7		57 24		54 5	29 30
		5 53 38		0 14						
16	0 6 16 59		+0 39		29 29,6	1 37 8		+ 4 28	54 9	29 32
		+ 5 54 16		0 48						
16½	0 12 11 15		0 57		29 33,7		61 52		54 17	29 36
		5 55 13		1 5						
17	0 18 6 28		1 13		29 39,2	0 35 16 S		+ 2 10	54 24	29 41
		5 56 26		1 36						
17½	0 24 2 54		2 0		29 47,2		64 2		54 35	29 46
		5 58 26		2 20						
18	1 0 1 20		2 40		29 58,8	0 28 46 N		− 0 16	54 46	29 53
		6 1 6		2 57						
18½	1 6 2 26		3 15		30 13,6		63 46		55 2	30 1
		6 4 21		3 30						
19	1 12 6 47		3 45		30 31,2	1 32 32		− 2 55	55 18	30 10
		6 8 6		4 6						
19½	1 18 14 53		4 28		30 51,7		60 51		55 37	30 20
		6 12 34		4 51						
20	1 24 27 27		5 14		31 15,8	2 33 23		− 5 48	55 57	30 30
		6 17 44		5 47						
20½	2 0 45 11		5 40		31 42,8		55 3		56 21	30 44
		6 23 24		5 58						
21	2 7 8 35		6 17		32 12,7	3 28 26		− 9 2	56 45	30 57
		6 29 41		6 28						
21½	2 13 38 16		6 40		32 45,1		46 1		57 12	31 12
		6 36 21		6 57						
22	2 20 14 37		7 14		33 19,4	4 14 27		−12 24	57 39	31 26
		6 43 35		7 15						
22½	2 26 58 12		7 16		33 56,1		33 37		58 8	31 42
		6 50 51		7 26						
23	3 3 49 3		7 37		34 33,3	4 48 4		−15 52	58 37	31 59
		6 58 28		7 28						
23½	3 10 47 31		7 19		35 10,6		17 45		59 5	32 13
		7 5 47		7 20						
24	3 17 53 18		7 21		35 47,3	5 5 49		−16 44	59 32	32 29
		7 13 8		6 58						
24½	3 25 6 26		6 35		36 22,1		1 1		59 57	32 42
		7 19 43		6 25						
25	4 2 26 9		6 15		36 54,2	5 4 48		+20 29	60 23	32 56
		7 25 58		5 32						
25½	4 9 52 7		4 49		37 21,9		21 30		60 42	33 6
		7 30 47		4 29						
26	4 17 22 54		4 9		37 44,3	4 43 18		+20 11	61 2	33 18
		7 34 56		3 23						
26½	4 24 57 50		2 37		38 1,2		41 41		61 13	33 24
		7 37 33		1 50						
27	5 2 35 23		1 3		38 20,4	4 1 37		+17 37	61 24	33 30
		7 38 36		0 53						
27½	5 10 13 59		0 43		38 24,8		59 18		61 26	33 31
		7 39 19								
28	5 17 53 18					3 2 19			61 28	33 32

Note, that the Sum of the two Latitudes of different Names is the firſt Difference.

A Table of the Sun's true Longitude, &c. with the Equation of Time.

1763 Feb.	☉'s tr. Long. at mean Noon.				½ Diurn. Incr. of Long.		Hourly Motion		Horizo. Diam.		Equ. of Time, ☉ ſlow.		Daily Diff.
days.	s	°	′	″	′	″	′	″	′	″	′	+ ″	″
1	10	12	27	58	30	24,5	2	32,1	32	33	14	5	7
2		13	28	47		24,		32,0		33		12	7
3		14	29	35		23,5		32,0		33		19	6
4		15	30	22		23,		31,9		32		25	4
5		16	31	8		22,		31,8		32		29	4
6		17	31	52		21,5		31,8		32		33	3
7		18	32	35		21,		31,7		31		36	3
8		19	33	16		20,		31,7		31		39	2
9		20	33	56		19,5		31,6		31		41	1
10		21	34	35		19,		31,6		30		42	1
11		22	35	13		18,		31,5		30		41	1
12		23	35	49		17,		31,5		29		40	1
13		24	36	23		16,5		31,4		29		39	2
14		25	36	56		15,5		31,3		28		37	3
15		26	37	27		15,		31,2		28		34	3
16		27	37	56		14,		31,2		28		31	4
17		28	38	25		13,		31,1		27		27	5
18		29	38	51		12,5		31,0		27		22	6
19	11	0	39	16		11,5		31,0		26		16	7
20		1	39	39		11,		30,9		26		9	7
21	11	2	40	1		10,		30,8		26	14	2	8
22		3	40	21		9,		30,7		25	13	54	8
23		4	40	39		8,		30,7		25		46	9
24		5	40	55		7,		30,6		24		37	10
25		6	41	9		6,5		30,5		24		27	10
26		7	41	22		5,5		30,5		23		17	11
27		8	41	34	30	4,5		30,4		23	13	6	11
28		9	41	43			2	30,4	32	22	12	55	

A Table to reduce into Degrees and Minutes of Longitude the Time of the Equator.

Hours of Time.	Degr. of Moti.	Min. Sec. Thi.	° ' ''	' '' '''	' '' '''	° ' ''	' '' '''
Hours.	Degr.	Tim.	Moti.		T.	Motion	
1	15	1	0	15	31	7	45
2	30	2	0	30	32	8	0
3	45	3	0	45	33	8	15
4	60	4	1	0	34	8	30
5	75	5	1	15	35	8	45
6	90	6	1	30	36	9	0
7	105	7	1	45	37	9	15
8	120	8	2	0	38	9	30
9	135	9	2	15	39	9	45
10	150	10	2	30	40	10	0
11	165	11	2	45	41	10	15
12	180	12	3	0	42	10	30
13	195	13	3	15	43	10	45
14	210	14	3	30	44	11	0
15	225	15	3	45	45	11	15
16	240	16	4	0	46	11	30
17	255	17	4	15	47	11	45
18	270	18	4	30	48	12	0
19	285	19	4	45	49	12	15
20	300	20	5	0	50	12	30
21	315	21	5	15	51	12	45
22	330	22	5	30	52	13	0
23	345	23	5	45	53	13	15
24	360	24	6	0	54	13	30
		25	6	15	55	13	45
		26	6	30	56	14	0
		27	6	45	57	14	15
		28	7	0	58	14	30
		29	7	15	59	14	45
		30	7	30	60	15	0

° or Degrees.
' Minutes.
'' Seconds.
''' Thirds.

Mean Motion of the Moon from the Sun.

Time.	Motion.		
H.	°	'	''
'	'	''	'''
''	''	'''	''''
1	0	30	29
2	1	0	57
3	1	31	26
4	2	1	54
5	2	32	23
6	3	2	52
7	3	33	20
8	4	3	49
9	4	34	18
10	5	4	46
11	5	35	15
12	6	5	43
15	7	37	9
20	10	9	32
25	12	41	55
30	15	14	19
35	17	46	42
40	20	19	5
45	22	51	28

Ti.	☽'s Inc. in Right Aſcen.	Dif. of Mer. in Ti.	in Lon.
60''	30''	2''	15'
30	15,	1,	7 1/2
15	7,5	0,5	3 3/4

The Three following Tables are inſerted in order to obtain the true Latitude of the Moon, by having given the true Longitude of the Sun and Moon and of the Node, by an Ephemeris, when the Latitude cannot be found near enough by Second Differences; which happens when the Moon's Latitude is near the greateſt, as will appear by the Tables, p. 45, 46.

Note, The greateſt Lat. happens when the Long. of the Moon is 3^s from her North or South Node.

But the Moon's Latitude may be found at any Time by the Three following Tables, thus: Reduce the Ecliptic Longit. to the Orbit Longit. by applying the Reduction Equat. contrary to its Title, and then work as directed at the Head of Tab. I. and II. of Latitude.

Note, This Reduct. need not be uſed when the Moon is at or near her greateſt Latitude, nor when near her Nodes, as appears by the Argument to enter the Table of Reduction with. When the Lat. per Tab. I. and the Correction, per Tab. II. are of the ſame Name, that is, both N. or S. then the Sum is the true Latit. otherwiſe their Difference is the true Latitude.

Reduction of the Moon's Orbit Place to the Ecliptic.
Arg. ☽'s Long. — Nodes.

☽−☊	0^s 6^s		1^s 7^s		2^s 8^s		☽−☊
	—		—		—		
°	′	″	′	″	′	″	°
0	0	0	6	2	6	2	30
1	0	14	6	9	5	55	29
2	0	29	6	15	5	47	28
3	0	43	6	21	5	39	27
4	0	58	6	27	5	30	26
5	1	12	6	32	5	20	25
6	1	26	6	37	5	10	24
7	1	41	6	41	5	0	23
8	1	55	6	45	4	50	22
9	2	9	6	48	4	39	21
10	2	23	6	51	4	28	20
11	2	37	6	54	4	17	19
12	2	50	6	56	4	5	18
13	3	3	6	57	3	53	17
14	3	16	6	57	3	41	16
15	3	29	6	57	3	29	15
16	3	41	6	57	3	16	14
17	3	53	6	57	3	3	13
18	4	5	6	56	2	50	12
19	4	17	6	54	2	37	11
20	4	28	6	51	2	23	10
21	4	39	6	48	2	9	9
22	4	50	6	45	1	55	8
23	5	0	6	41	1	41	7
24	5	10	6	37	1	26	6
25	5	20	6	32	1	12	5
26	5	30	6	27	0	58	4
27	5	39	6	21	0	43	3
28	5	47	6	15	0	29	2
29	5	55	6	9	0	14	1
30	6	2	6	2	0	0	0
°	+		+		+		°
—							—
	11	5	10	4	9	3	

Signs and Degrees.

Note, That ☽ — ☊ denotes the Long. or Place of the Node ſubtracted from the Long. of the Moon; and the like of the reſt.

TABLE I. Of the Moon's Latitude.

Enter with Argument of Latitude.

Argum. the Lon. of the ☽ — the Node.

☽ — ☊	0^s N. La.	1^s N. La.	2^s N. La.	☽ — ☊
	6 S. Lat.	7 S. Lat.	8 S. Lat.	
°	° ′ ″	° ′ ″	° ′ ″	°
0	0 0 0	2 34 25	4 27 38	30
1	0 5 23	2 39 4	4 30 18	29
2	0 10 46	2 43 39	4 32 53	28
3	0 16 9	2 48 12	4 35 22	27
4	0 21 32	2 52 42	4 37 47	26
5	0 26 54	2 57 9	4 40 7	25
6	0 32 16	3 1 33	4 42 21	24
7	0 37 37	3 5 53	4 44 30	23
8	0 42 58	3 10 10	4 46 34	22
9	0 48 18	3 14 23	4 48 33	21
10	0 53 37	3 18 33	4 50 27	20
11	0 58 56	3 22 39	4 52 1	19
12	1 4 11	3 26 42	4 53 58	18
13	1 9 27	3 30 41	4 55 36	17
14	1 14 42	3 34 36	4 57 8	16
15	1 19 55	3 38 27	4 58 35	15
16	1 25 6	3 42 14	4 59 56	14
17	1 30 16	3 45 57	5 1 12	13
18	1 35 24	3 49 36	5 2 22	12
19	1 40 31	3 53 11	5 3 26	11
20	1 45 36	3 56 41	5 4 25	10
21	1 50 39	4 0 7	5 5 19	9
22	1 55 40	4 3 29	5 6 7	8
23	2 0 39	4 6 47	5 6 50	7
24	2 5 36	4 9 57	5 7 26	6
25	2 10 30	4 13 7	5 7 57	5
26	2 15 22	4 16 11	5 8 27	4
27	2 20 12	4 19 10	5 8 43	3
28	2 24 59	4 22 4	5 8 57	2
29	2 29 43	4 24 53	5 9 5	1
30	2 34 25	4 27 38	5 9 8	0
☽ — ☊	11^s S. Lat.	10^s S. Lat.	9^s S. Lat.	☽ — ☊
	5 N. La.	4 N. La.	3 N. La.	

TAB. II. Correction of the Latit.

Argument.

$\overline{☽ - ☉ \times 2}$, — Arg. 1^s Lat.

Degr.	0^s N.	1^s N.	2^s N.	Degr.
	6 S.	7 S.	8 S.	
°	′ ″	′ ″	′ ″	°
0	0 0	4 25	7 39	30
1	0 9	4 33	7 43	29
2	0 19	4 41	7 48	28
3	0 28	4 49	7 52	27
4	0 37	4 56	7 56	26
5	0 46	5 4	8 0	25
6	0 55	5 11	8 4	24
7	1 5	5 19	8 7	23
8	1 14	5 26	8 11	22
9	1 23	5 34	8 14	21
10	1 32	5 41	8 18	20
11	1 41	5 48	8 21	19
12	1 50	5 55	8 24	18
13	1 59	6 2	8 27	17
14	2 8	6 9	8 30	16
15	2 17	6 15	8 32	15
16	2 26	6 22	8 34	14
17	2 35	6 28	8 36	13
18	2 44	6 34	8 38	12
19	2 52	6 40	8 40	11
20	3 1	6 46	8 42	10
21	3 10	6 52	8 43	9
22	3 18	6 57	8 45	8
23	3 27	7 3	8 46	7
24	3 35	7 8	8 47	6
25	3 44	7 14	8 48	5
26	3 52	7 19	8 48	4
27	4 1	7 24	8 49	3
28	4 9	7 29	8 49	2
29	4 17	7 34	8 50	1
30	4 25	7 39	8 50	0
	11^s S.	10^s S.	9^s S.	
	5 N.	4 N.	3 N.	

The Uſe of the foregoing Table.

To find the greateſt Latitude the Moon will have between the 28th and 29th (at Noon) January 1763.

	s	°	′
At the Foot of the Table of the Sun's Longitude, in p. 44, I find the Long. of the Node the 28th of Jan. at 6 P. M.	=0	27	18
	+3	0	0
Long. of the Moon at her greateſt Lat.	3	27	18
Long. of ditto the 28th at Noon, per p. 45,	=3	24	36
Hence the Moon has to make in Long.	0	2	42

Now if 7° 26′ 38″ require 12^h, what will 2° 42′, viz. $4^h\ 36'$, the Time P. M. when the Moon will have her greateſt Latitude?

To find the greateſt Latitude.

	°	′	″	
Moon's Long. 3^s from the Node (or Arg. of Lat.) gives	5	9	8	N. Lat.

	s	°	′
☽'s true Long. then =	3	27	18
☉'s ditto, per p. 44, =	10	8	37
☽ — ☉ =	5	18	41
2 × ☽ — ☉ =	11	7	22
—Arg. 1ſt Lat. =	3	0	0
Arg. of 2d. Lat. =	8	7	22

	°	′	″	
Arg. of 2d Lat. gives	0	8	8	S. Lat.
Rem. the greateſt Lat.	5	1	0	N.

Now let it be required to find the true Lat. of the Moon at $10^h\ 40'$ P. M.

	s	°	′	″
Per Tab. p. 45, I find the Long. of the Moon the 28th =	3	24	36	32
Increaſe of Long. in $10^h\ 40'$ +		6	36	49
Long. of the Moon	4	1	13	21
Ditto of the Node	0	27	17	30
☽ — ☊	3	3	56	

	s	°	′
☽'s Long.	4	1	13
☉'s ditto —	10	8	52
☽ — ☉ =	5	22	21
2 × ☽ — ☉ =	11	14	42
—Arg. 1ſt Lat. =	3	3	56
Arg. of 2d Lat. =	8	10	46

☽ — ☊ 3^s 3° 56′ gives Lat. 5° 8′ 28″ N.

Arg. of 2d Lat. 8 10 46 gives ditto — 8 20 S.

☽'s true Lat. at $10^h\ 40'$ P. M. = 5 0 8 N.

Note, That the Increaſe of Lat. in $4^h\ 36'$ is = 15″ and the Decreaſe of ditto in $6^h\ 4'$ is = 52 } which ſelf-evidently ſhews the Truth of the Operation.

The

The Uſe of the Table in Page 49.

Required to reduce 15^h $52'$ $25''$ into Degrees and Minutes of the Equator.

	°	′	″	
Thus, under the Hours of Time, and againſt 15^h is	225	0		
and for $52'$ is	13	0		
for $25''$ is		6	15	
Hence 15^h $52'$ $25''$ gives	238	6	15	as required.

	°	′		′	″
Required to reduce	117	49,7 into Time.			
Thus, 7^h =	105				
Remains	12	49,7			
0^h $51'$ =	12	45,0			
Rem.	0	4,7	=	4	42
0 0 $19''$			=	4	45
Hence 7 51 19 the Time required.					

Remark 1. That from the 23d of Dec. to the 15th of April, and from the 15th of June to the 31ſt of Auguſt, mean Time is faſter than apparent Time; hence, add the Equation of Time to the Time obtained by the Altitude of the Sun, and the Sum will be mean Time.

Remark 2. From the 15th of April to the 15th of June, and from the 31ſt of Auguſt to the 23d of December, mean Time is ſlower than apparent Time; therefore ſubtract the Equation of Time from the ſolar or apparent Time, and the Remainder will be the mean Time; which Time muſt be taken in making uſe of the Longitude, &c. of the Sun and Moon in February, in the Table foregoing, becauſe the calculated Places are to mean Time; then apply the aſſumed Difference of Longit. and work in all Reſpects as before directed.

A TABLE of the Time that the Moon paſſes the Meridian of London, for the Years 1763 and 1764; with her Declination at the Noon of that Day (before ſhe arives at the Meridian) for ſuch Days whereon the Moon's Meridian Altitude may be taken, in order to obtain the Latitude of the Ship or Place.

1763 Days.	☽ on Merid.		☽'s Decl.		Days.	☽ on Merid.		☽'s Decl.		Days.	☽ on Merid.		☽'s Decl.	
Jan.	h	'	°	'		h	'	°	'		h	'	°	'
24	7	33	22	32 N	23	7	6	28	0 N	21	7	34	8	38 N
25	8	28	25	51	24	8	6	25	43	22	8	24	1	56
26	9	29	27	41	25	9	5	22	12	23	9	11	4	54 S
27	10	31	27	54	26	10		17	4	24	10	4	11	30
28	11	33	26	11	27	10	53	10	45	25	10	57	17	32
29	12	34	22	39	28	11	45	3	42	26	11	53	22	30
30	13	32	17	36	29	12	40	3	23 S	27	12	51	26	2
31	14	25	11	26	30	13	32	10	21	28	13	52	27	57
Feb. 1	15	12	4	38	31	14	24	16	38	29	14	52	28	10
2	16		2	13 S	Apr. 1	15	22	21	46	30	15	43	26	45
3	16	52	8	51	2	16	20	25	34	31	16	33	23	59
4	17	42	14	52	3	17	16	27	41	June 1	17	19	20	13
5	18	31	20	2	4	18	12	28	20	2	18	1	15	38
6	19	25	24	2	5	19	6	27	26	3	18	41	10	28
7	20	20	26	47	6	19	56	25	11	4	19	20	5	4
16	2	30	1	2 N	7	20	42	21	43	5	20		0	32 N
17	3	10	6	36	17	3	12	26	29 N	6	20	40	6	12
18	3	50	12	2	18	4	8	28	7	16	4	38	15	56 N
19	4	34	17	4	19	5	6	28	14	17	5	28	9	55
20	5	22	21	10	20	6	4	26	41	18	6	15	3	21
21	6	14	25	16	21	7	1	23	35	19	7	3	3	23 S
22	7	10	27	30	22	7	56	18	58	20	7	53	9	45
23	8	12	28	13	23	8	48	13	13	21	8	42	15	53
24	9	13	27	15	24	9	39	6	40	22	9	36	21	4
25	10	15	24	31	25	10	30	0	15 S	23	10	34	25	2
26	11	12	20	6	26	11	21	7	19	24	11	33	27	31
27	12	8	14	24	27	12	16	13	55	25	12	30	28	16
28	13	2	7	38	28	13	11	19	16	26	13	26	27	20
Mar. 1	13	55	0	30	29	14	9	23	32	27	14	20	25	1
2	14	46	6	32 S	30	15	8	26	31	28	15	6	21	29
3	15	37	13	4	May 1	16	7	28	21	29	15	51	17	5
4	16	31	18	44	2	17	3	27	56	30	16	32	12	5
5	17	26	23	15	3	17	55	26	1	July 1	17	11	6	40
6	18	21	26	23	4	18	42	22	56	2	17	50	1	7
7	19	16	28	3	5	19	26	18	54	3	18	30	4	34 N
8	20	11	28	10	6	20	6	14	10	4	19	10	10	0
18	2	36	15	56 N	7	20	46	9	0	5	19	55	15	12
19	3	24	20	23	17	4	2	27	10 N	6	20	43	19	52
20	4	12	24	33	18	4	59	24	21	16	4	57	2	3 S
21	5	7	27	1	19	5	53	20	8	17	5	44	8	39
22	6	5	28	15	20	6	44	14	48	18	6	35	14	40

1763 Days.	☽ on Merid.		☽'s Decl.		Days.	☽ on Merid.		☽'s Decl.		Days.	☽ on Merid.		☽'s Decl.	
July	h	'	°	'		h	'	°	'		h	'	°	'
19	7	27	20	8 S	15	7	14	28	41 S	12	6	38	18	48 S
20	8	25	24	18	16	8	8	27	14	13	7	20	13	58
21	9	20	27	3	17	9	0	24	37	14	8	0	8	38
22	10	17	28	15	18	9	50	20	55	15	8	39	2	58
23	11	13	27	49	19	10	34	16	21	16	9	18	2	37 N
24	12	7	25	53	20	11	14	11	12	17	9	58	8	12
25	12	55	22	41	21	11	54	5	43	18	10	37	13	32
26	13	39	18	28	22	12	33	0	4	19	11	23	18	26
27	14	25	13	34	23	13	12	5	37 N	20	12	10	22	32
28	15	5	8	12	24	13	54	11	2	21	13	2	25	49
29	15	44	2	40	25	14	37	16	7	22	13	56	27	51
30	16	23	3	2 N	26	15	24	20	42	23	14	51	28	28
31	17	3	8	28	27	16	13	24	23	24	15	47	27	35
Aug. 1	17	46	13	44	28	17	7	27	5	25	16	40	25	9
2	18	32	18	32	29	18	3	28	28	26	17	32	21	18
3	19	22	22	42	30	19	0	28	25	27	18	22	16	20
4	20	17	25	54	Oct. 1	19	58	26	43	28	19	9	10	28
14	4	32	13	32 S	11	4	15	27	49 S	29	19	57	3	57
15	5	25	19	12	12	5	15	28	36	30	20	46	3	0 S
16	6	19	23	38	13	6	12	27	48	Dec. 1	21	36	9	43
17	7	16	26	43	14	7	5	25	27	11	6	6	10	6 S
18	8	13	28	18	15	7	55	21	57	12	6	48	4	33
19	9	10	28	14	16	8	40	17	34	13	7	27	1	4 N
20	10	5	26	37	17	9	21	12	35	14	8	5	6	42
21	10	55	23	43	18	10	2	7	10	15	8	43	12	2
22	11	42	19	46	19	10	41	1	32	16	9	24	17	4
23	12	24	14	58	20	11	19	4	7 N	17	10	6	21	26
24	13	6	9	46	21	12	2	9	37	18	10	54	25	0
25	13	46	4	12	22	12	43	14	52	19	11	43	27	23
26	14	25	1	27 N	23	13	28	19	35	20	12	36	28	24
27	15	4	7	2	24	14	16	23	33	21	13	29	27	51
28	15	46	12	25	25	15	9	26	30	22	14	24	25	46
29	16	30	17	27	26	16	3	28	15	23	15	17	22	10
30	17	18	21	40	27	17	0	28	32	24	16	6	17	21
31	18	10	25	10	28	17	56	27	20	25	16	56	11	35
Sept. 1	19	7	27	33	29	18	51	24	29	26	17	41	5	12
2	20	5	28	33	30	19	42	20	20	27	18	28	1	25 S
11	3	25	17	38 S	31	20	32	14	58	28	19	16	8	7
12	4	20	22	44	Nov. 9	4	2	28	10 S	29	20	9	14	25
13	5	19	26	13	10	5	0	26	16	30	21	4	19	56
14	6	17	28	13	11	5	51	23	4	31	22	0	21	22

1764 Days. Jan.	☽ on Merid.		☽'s Decl.		Days.	☽ on Merid.		☽'s Decl.		Days.	☽ on Merid.		☽'s Decl.	
	h	'	°	'		h	'	°	'		h	'	°	'
7	3	28	12	18 S	Mar. 6	2	36	12	47 N	May 5	3	31	28	36 N
8	4	8	6	16	7	3	18	17	41	6	4	25	27	30
9	4	49	0	34	8	4	2	21	56	7	5	18	25	1
10	5	26	5	6 N	9	4	51	25	23	8	6	9	21	12
11	6	6	10	31	10	5	42	27	40	9	7		16	16
12	6	47	15	41	11	6	36	28	41	10	7	47	10	24
13	7	32	20	15	12	7	33	28	16	11	8	36	3	54
14	8	21	24	14	13	8	30	26	5	12	9	25	3	1 S
15	9	13	26	50	14	9	24	22	46	13	10	17	9	59
16	10	8	28	18	15	10	17	17	55	14	11	13	16	29
17	11	6	28	16	16	11	9	11	50	15	12	13	22	2
18	12	3	26	36	17	12		5	1	16	13	17	26	5
19	12	58	23	23	18	12	52	2	10 S	17	14	23	28	15
20	13	50	18	46	19	13	44	9	18	18	15	26	28	23
21	14	39	13	4	20	14	40	15	49	19	16	24	26	49
22	15	28	6	40	21	15	38	21	24	20	17	17	23	24
23	16	16	0	1 S	22	16	38	25	36	21	18	4	19	4
24	17	4	6	49	23	17	40	28	6	22	18	47	13	58
25	17	55	13	15	24	18	39	28	45	23	19	28	8	26
26	18	50	18	57	25	19	37	27	41	24	20	8	2	40
27	19	46	23	33	26	20	30	25	3	25	20	47	3	3 N
Feb. 6	3	15	3	26 N	Apr. 6	3	44	27	8 N	June 3	3	10	25	36 N
7	3	35	9	1	7	4	37	28	32	4	4	5	22	4
8	4	36	14	14	8	5	31	28	34	5	4	54	17	25
9	5	19	18	59	9	6	26	27	6	6	5	41	11	44
10	6	6	22	31	10	7	21	24	11	7	6	27	5	37
11	6	56	26	7	11	8	12	19	55	8	7	13	1	1 S
12	7	50	28	5	12	9	3	14	27	9	8	3	7	44
13	8	46	28	37	13	9	54	7	38	10	8	55	14	13
14	9	43	27	34	14	10	44	1	7	11	9	52	19	57
15	10	40	24	56	15	11	36	6	3 S	12	10	55	24	35
16	11	35	20	43	16	12	30	13		13	11	59	27	32
17	12	28	15	14	17	13	29	19	11	14	13	2	28	30
18	13	18	8	54	18	14	32	24	5	15	14	4	27	27
19	14	8	2	31	19	15	36	27	20	16	15	1	24	40
20	14	58	4	59 S	20	16	38	28	38	17	15	52	20	33
21	15	50	11	44	21	17	35	28	6	18	16	38	15	34
22	16	44	17	48	22	18	31	25	51	19	17	20	10	2
23	17	40	22	48	23	19	22	22	17	20	18		4	25
24	18	39	26	23	24	20	7	17	44	21	18	40	1	31 N
25	19	39	28	21	25	20	48	12	34	22	19	19	7	12
26	20	38	28	34						23	20	1	12	37

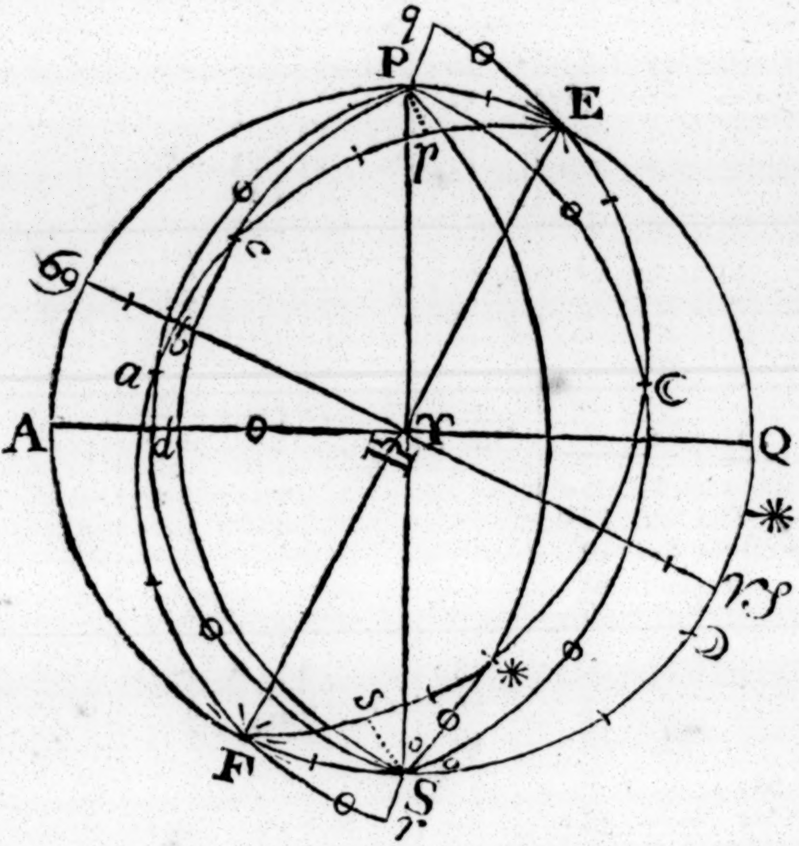
1764 Days. July	☽ on Merid.		☽'s Decl.	
	h	′	°	′
3	3	34	12	59 N
4	4	20	6	50
5	5	6	0	20
6	5	53	6	15 S
7	6	42	12	43
8	7	36	18	29
9	8	33	23	22
10	9	35	26	47
11	10	38	28	25
12	11	41	28	6
13	12	41	25	57
14	13	35	22	15
15	14	24	17	26
16	15	8	11	57
17	15	51	6	7
18	16	31	0	10
19	17	11	5	47 N
20	17	53	11	14
21	18	36	16	14
22	19	21	20	41
23	20	10	24	22
Aug. 1	3	5	1	43 N
2	3	50	4	59 S
3	4	38	11	29
4	5	30	17	24
5	6	26	22	26
6	7	55	26	10
7	8	27	28	17
8	9	29	28	31
9	10	29	26	56
10	11	24	23	44
11	12	15	19	16
12	13	3	13	58
13	13	46	8	10
14	14	27	2	11
15	15	8	3	44 N
16	15	50	9	26
17	16	32	14	46
18	17	17	19	28
19	18	4	23	25
20	18	56	26	30
21	19	48	28	13

Days.	☽ on Merid.		☽'s Decl.	
	h	′	°	′
Sept. 1	4	25	21	7 S
2	5	25	25	32
3	6	27	28	1
4	7	28	28	43
5	8	28	27	36
6	9	24	24	51
7	10	16	20	47
8	11	3	15	45
9	11	49	10	8
10	12	31	4	11
11	13	12	1	56 N
12	13	53	7	40
13	14	35	13	7
14	15	19	18	5
15	16	6	22	18
16	16	56	25	37
17	17	48	27	47
18	18	41	28	44
19	19	35	28	19
20	20	29	26	26
Oct. 1	5	31	28	42 S
2	6	32	28	2
3	7	30	25	42
4	8	23	21	58
5	9	10	17	6
6	9	55	11	39
7	10	38	5	52
8	11	19	0	3 N
9	11	59	5	56
10	12	41	11	32
11	13	24	16	38
12	14	9	21	5
13	15		24	41
14	15	48	27	12
15	16	40	28	33
16	17	33	28	28
17	18	25	27	7
18	19	16	24	23
19	20	5	20	29
20	20	53	15	24
29	4	28	28	18 S
30	5	29	26	18

Days.	☽ on Merid.		☽'s Decl	
	h	′	°	′
31	6	23	22	47 S
Nov. 1	7	13	18	13
2	7	59	12	56
3	8	40	7	12
4	9	22	1	19
5	10	1	4	29 N
6	10	42	10	6
7	11	24	15	23
8	12	8	19	55
9	12	54	23	44
10	13	45	26	31
11	14	36	28	12
12	15	28	28	30
13	16	20	27	28
14	17	10	25	6
15	17	58	21	33
16	18	44	16	55
17	19	30	11	29
18	20	15	5	19
27	4	9	23	53 S
28	5	2	19	31
29	5	49	14	8
30	6	33	8	35
Dec. 1	7	14	2	39
2	7	54	3	13 N
3	8	34	8	52
4	9	15	14	10
5	9	58	18	53
6	10	44	22	53
7	11	33	25	56
8	12	23	27	51
9	13	15	28	26
10	14	7	27	48
11	14	58	25	37
12	15	44	22	20
13	16	30	17	54
14	17	14	12	42
15	17	59	6	47
16	18	45	0	28
17	19	32	6	2 S
18	20	25	12	28

A Projection on the Plane of the Solſtitial Colure.

Let the Point denoted by *a* repreſent the projected Place of Aldebaran, whoſe Longitude ♈*b*, and Latitude *a b*, are given, to find *a d* the Declination, and ♈*d* the Right Aſcenſion.



Note 1. By the Projection of the Points *a b c d p q* ☽ ✱, &c. it is evident, that when the Longitude of the Moon or a Star is 3 Sines or 9 Sines, that the Moon or Star is then in the Solſtitial Colure, and then the Latitude (of the ☽ or ✱) added to the Obliquity $\left\{\begin{matrix}♋\ A \\ Q\ ♑\end{matrix}\right\}$ or ſubtracted therefrom, gives the Declination; becauſe in this Poſition the Circle of Long. coincides with the Meridian.

Note 2.

Note 2. When the Longitude of the Moon or a Star is leſs than 3 Sines, then 3 Si. — the Long. gives the contained Angle at E or F, the Poles of the Ecliptic. If the Longitude be greater than 3 Sines and leſs than 6 Sines, then the Long. — 3 Si. gives the contained Angle.

If the Longitude be greater than 6 Sines and leſs than 9 Sines, then 9 Si. — the Long. gives the contained Angle. If the Longitude be greater than 9 Sines and leſs than 12 Sines, then the Long. — 9 Si. gives the contained Angle between the two given Sides.

Note 3. The Side whereon the Perpendicular falls within the primitive Circle, from S or P (the Poles of the Equinoctial) will always be equal to 90° + or — the Latitude of the Moon or Star; but if the Perpendicular falls without the Prim. then the Arc without (as Eq or Fr) is the 4th Proportional (and equal to $Ep = Fs$) which being added to the the Co-Lat. (or its Supplement) gives the 5th Arc.

Note 4. If the Latitude be $\left\{\begin{matrix}\text{N. and the Long. leſs,}\\ \text{S. and the Long. greater,}\end{matrix}\right\}$ than 6 Sines, the Perpendicular falls within the Prim. and then the Co-Lat. — 4th Arc gives the 5th Arc. But if the Latitude be $\left\{\begin{matrix}\text{S. and the Long. leſs,}\\ \text{N. and the Long. greater,}\end{matrix}\right\}$ than 6 Sines, the Perpendicular falls without the Prim. and then the Co-Lat. + 4th Arc gives the 5th Arc.

In the Spherical Triangle $aPEa$ are given

° ′ ″
The Angle $PEa = 23\ \ 31\ \ 21$ the Longitude to (♋) Cancer,
The Side $PE = 23\ \ 28\ \ 21$ the Obliquity of the Ecliptic,
And the Side $aE = 95\ \ 29\ \ 0$ the Lat. of the Star (Aldebaran) $+90°$,
To find aP, the Co-Decl. and $aPE =$ the Right Aſcen. $+ 90°$,
Hence the Angle $aPE - 90° =$ the Right Aſcen.

1. In the Triangle PEp, the Co-ſine $E + R =$ Co-tang. $EP +$ Tang. Ep.
Hence, R : Tang. EP : : Co-ſine E : Tang. $Ep = 21°\ 42'\ 37''$ the 4th Arc,
and $aE - Ep$ $= 73\ \ 46\ \ 23$ the 5th Arc.

2. As the Co-ſine 4th Arc, Co-ar. : Co-ſine 5th : : Co-ſine PE (the Obliquity) : the Co-ſine $aP = 73°\ 59'\ 7''$, or to the Sine of $ad = 16°\ 0'\ 53''$ the Decl.

Now we have given the Three Sides of the Triangle $aPEa$, to find the Angle aPE, which may be found by the general Method, thus:

From Half the Sum of the Three Sides take (ſeparately) each of the Sides, containing the Angle required; then to the Sines Co-ar. of the containing Sides add the Sines of the Two Differences, and Half the Sum of the Logar. Sines is the Sine of Half the Angle required: Whence the Right Aſcenſion $=\left\{\begin{matrix}65°\ 35'\ 2''\\ 4^h\ 22'\ 20''\end{matrix}\right\}$

Wherefore,

Wherefore, by having given the Long. and Lat. of the Moon or a Star, the Decl. or Right Aſcen. may be readily found. But obſerve, when the Lat. of a Star, &c. is ſuch, that it cannot be known from the Projection whether the Decl. be N. or South or (o); that is, ſuppoſing a Star poſited at *d*, or ſome little North or South thereof, as in the Triangle *arSa*, having given *a*F, FS, and the Supplement of the contained Angle *a*F♋, to find *a*S.

1. In the Triangle FS*r* (right-angled at *r*) are given FS and the Angle SF*r* = Angle *a*F♋, it being vertical, and therefore equal, to find the Leg F*r*, the 4th Arc,

Say, as R : Tang. FS : : Coſine F : Tang. F*r* = 21° 42′ 37″.

2. As Co-ſine F*r* : Co-ſine FS : : Co-ſine *ar* : Co-ſine *a*S. But obſerve, that if *ar* be leſs, equal to, or greater than 90°, ſo will *a*S be leſs, equal to, or greater than 90° alſo, becauſe of the Legs *ar* and *r*S being of the ſame, or of different Affection; that is, both leſs (equal to) or one greater and the other leſs than 90° or a Quadrant.

	°	′	″	
Now to F*r* =	21	42	37	
+90°—Lat. = F*a* =	84	31	0	
5th Arc *ar* =	106	13	37	
Its Suppl. =	73	46	23	= *a*P.

Wherefore the Supple. *a*S will be found = 73° 59′ 7″ and therefore
*a*S = 106 0 53 and
*a*S–90° = 16 0 53 the Declin. as before.

The Method of finding the Declination and Parallax of the Moon has been ſhewn in the Uſes of the Tables foregoing; I am now going to ſhew the Method of obtaining the Latitude of a Ship at Sea by obſerving the Meridian Altitude of the Moon. The following Obſervation was made on board the Prince Henry Indiaman.

	°	′
1761, At 8 P. M. Mar. 15, I obſerved the Mer. Alt. ☽'s lower Edge =	33	16
+½ the Diam. 16′ — the Dip 5 } add the Diff.	0	11
	33	27
Hor. Paral. 59′, Paral. of Alt. add		49
True Alt. obſerved	34	16
Z. Diſt.	55	44 N
Declin.	25	28 N
Lat. in	30	16 S
Lat. in by Account ſince Noon	39	15

Of the Obliquity of the Ecliptic.

Long.	Node.	Obliq. of the Ecl.			Equ. of the Equinox.	
s	°	°	'	''	''	
0	0	23	28	39,7	0,0	
6	0	23	28	20,3	0,0	
3	0	23	28	30,0	−18,1	the greateſt Equa. which being applied, gives the true Obliq.
9	0				+18,1	

I have been a little prolix about explaining the general Method to be uſed for obtaining the Requiſites of this uſeful Problem, not having ſeen (in any Author I have read) a Scheme or Projection that might ſerve as a general one for all Circumſtances of the Situation of the Moon, Stars, &c. which this Figure does, together with the Notes, &c. whereby the Solution to all Caſes relating to Longitude, Latitude, Declination, and Right Aſcen. may be obtained without Ambiguity.

Six Neceſſary Remarks relating to the Declination of the Moon.

To find the Longitude in the Moon's Orb of the greateſt Declination, through a Revolution of the Nodes.

I. The Longitude of the North Node (☊) being $\left\{\begin{matrix}12 \text{ Sines}\\ \text{or } 0\end{matrix}\right\}$ then the Long. in the Moon's Orb of 3 Si. and 9 Si. are the Places of greateſt Decl. North and South, and are equal to the Obliquity of the Ecliptic + the Moon's Lat.

II. The Node moving retrograde from $\left\{\begin{matrix}12 \text{ Sines}\\ \text{or } 0\end{matrix}\right\}$ to 9 Sines, in which Time the Places of the greateſt Declination (in the Moon's Orb) will move

$$\left\{\begin{matrix}\text{direct from 9 Sines to 9 Si.} & 11° & 41' & 04''\\ \text{retrograde from 3 Si. to 2 Si.} & 18 & 18 & 56\end{matrix}\right\}$$

(the Obliquity of the Ecliptic being 23° 28′ 20″, and the Inclination of the Moon's Orb to the Ecliptic = 5° 9′ 8″); and when the Place of the Node becomes 9 Sines, the Decl. will be = 23° 59′ 40″.

III. The Node moving from 9 Sines to 6 Sines, in which Time the Places of the greateſt Declination will move from 2 Si. 18 Degr. &c. direct to 3 Si. and retrograde from 9 Si. 11° 41′ 4″ to 9 Si. And when the Longitude of the Node becomes 6 Si. the Places of greateſt Decl. are 9 Si. and 3 Si. and then the greateſt Decl. will be = the Obliquity — the Lat. = 18° 19′ 12″; the Obliquity and Inclination being as before.

IV. The Node moving from 6 Sines to 3 Sines, in which Time the Places of greateſt Declination will move retrograde from 9 Si. to 8 Si. 18° 18′ 56″, and direct from 3 Si. to 3 Si. 11° 41′ 4″, and the Decl. in thoſe Places will be as in Remark II. foregoing.

V. The Node moving from 3 Sines to 0 Sines, in which Time the Places of greateſt Decl. will move from 8 Si. 18° 18′ 56″ to 9 Si. and from 3 Si. 11° 41′ 4″ to 3 Si. and then the Places of greateſt Decl. are as in Remark I.

VI.

Lon. of the ☊.						
s.		s.			s.	
0	then the Lon. in the Orb	3	is the Pl. of greateſt Lat.	N. and	9	of Lat. S.
3	ditto	6	ditto	N. and	0	of ditto.
6	ditto	9	ditto	N. and	3	of ditto.
9	ditto	0	ditto	N. and	6	of ditto.

The Lon. of the Node being 3 Si. or 9 Si. (as in Remarks II. and IV.) let it be required to find the Places in the Orb that will have the greateſt Decl. and alſo the Decl. at that Time.

Say, as R : Co-tang. of the Obliqu. 23° 28′ 20″ = 10,3622742
: : Sine of the Inclination 5 9 8 = 8,9532865
: Tang. of the Diſt. from ♋ or ♑ = 11 41 3½ = 9,3155607

	s	°	′	″		°	′	″	
Now per Note 2. p. 58. Lon. of the Orb	8	18	18	56	Lat.	1	2	26	S.
Ditto of the ☊	9	0	0	0	Co-Lat.	88	57	34	
☽ — ☊ =	11	18	18	56					

	°	′	″	
For the Decl. R : Tang. of the Obliqu.	23	28	20	= 9,6377258
: : Co-ſine of the Diſt. from {♋ ♑}	11	41	4	= 9,9909050
: Tang. of the 4th Arc	23	2	14	= 9,6286308
Co-Lat.	88	57	34	
Remains 5th Arc =	65	55	20	

As Co-ſine Co-ar. 4th = 0,0360930
: Co-ſine 5th = 9,6106350
: : Co-ſine of Obliqu. = 9,9624893

: Sine Decl. 23° 59′ 40″ = 9,6092173 as required.

Note, In like Manner the Ecliptic, Longitude of the Moon, the Time of her greateſt Declination, and her Declination at that Time (in any Poſition of the Node) may be found.

To

To find the Difference of Longitude of Places.

The Latitude of Union Caſtle in the Iſland of St. Helena is 15° 56′ S. and Long. 5° 49′ W. from London, or 5° 54′ from Greenwich, as obtained by the following Obſervations; which Method of finding the Difference of Meridians (or Longitude of Places) I think, is greatly ſuperior, and ought to be preferred, to thoſe of the Satellites.

			h	′	″
1761,					
June 22,	At St. Helena the ☽'s Sidereal Tranſit,	2d Limb	22	31	47,2
	At Greenwich ditto	2d ditto	22	31	2,2
	☽'s Alt. at St. Helena 89° } nearly.				
	Ditto at Greenwich 23½ }	Diff.			45,0

Note, that 65½ Diff. of Alt. gives 13″, the Augmentation of the Semi-diameter of the Moon at St. Helena more than at Greenwich, occaſioned by the nearer Approach of the Moon to the Zenith of that Place; which 13″ of apparent Increaſe gives 1″ of Time nearly, that the Half Diameter of the Moon was in paſſing the Meridian at St. Helena more than at Greenwich, which is allowed for in the Time of the Tranſit above.

	′	″
The hourly Mo. of the ☽	=31,0	=1860
Ditto ⊙	= 2,4	= 144
Moon from the Sun per Hour		=1716

Diff. of Ri. Aſc. in Time 45,0″=675,0″ Mo.

Now, as 1716″, the hourly Motion of the ☽—⊙ in Right Aſcenſion is to 15° of Longitude, ſo is 675″ of Right Aſcenſion to 5° 54′ W. the Longitude from Greenwich to St. Helena.

Note, The different Denſities of the Air, and thin Vapours therein, make no Difference in the Tranſit Obſervations, but affect the Satellite Obſervations greatly.

The Variation of the Needle at St. Helena 11° 36′ W. being the Mean of Six Obſervations with the Compaſs belonging to the Royal Society applied to the Meridian Line.

	°	′
The Dip of the South Point of the Needle below the Horizon	7	45
being the Mean of 12 Obſerv. The Dip at London, N. Point	73	25
Hence the Dip of the South Point from London to St. Helena=	81	10
The Variation of the Needle, in March 1762, at London=	19	45 W.

The

The greateſt Heat I obſerved at St. Helena, by a Farenheit's Thermometer, on my Voyage from thence, and in London, at the Times as follows;

At St. Helena.		At Sea.		Lat. of the Ship.	At the Academy in Miles's Lane.	
					1762,	°
1761,	°	1761,	°	°	July 11,	74
April 22,	76	July 8,	75	8½ S.	12,	76
23 to 26,	74 to 75	9,	75	8	13,	77
to May 1,	73	10 to 29,	76	12 N.	14,	75
7,	74	30 and 31,	76½	13	15 and 16,	74
8,	76	Aug. 1 to 3,	76	14	17, 18, 19,	75
9,	76	4 to 22,	75½	36	20,	74
10,	74	23 to 29,	75	37½ N.	21 and 22,	75
					23,	76
					24 and 25,	74

The greateſt Heat in London, in the Year 1762, was the 13th of July, which exceeded thoſe at St. Helena and on the Voyage; although we were becalmed a conſiderable Time, when the Sun paſſed near our Zenith.

The greateſt Height of the Quickſilver in the Barometer at St. Helena, as obſerved in the Valley } = 30,14 Inches.
The leaſt Height obſerved = 29,99

The greateſt Variation obſerved 0,15

The greateſt ditto upon the Hill = 0,05 where we had an Obſervatory.

The mean Height of the Barometer in the Valley = 30,096 Inches; which reduced to that of a Level with the Surface of the Sea is = 30,1 = 28,25 Inches Fr. = 28 Inches 3 Lines, the Thermometer being from 58 to 61.

		Barom.	
1761, June 14,	In the Valley	30,05	Inches.
	At the Obſervatory	28,01	
	The Fall in the Tube	2,04	
	Add the Riſe in the Baſon	0,013	
	The true Fall	2,053	

The Surface of the Quickſilver in the Tube being to that in the Baſon nearly as 1 to 160; and, by the Fifteenth of the Twelfth of Euclid, equal Cylinders have the Areas of their Baſes and Altitudes reciprocally proportional. Hence the Riſe in in the Baſon to the Fall in the Tube is in direct Ratio to the Surfaces: therefore, as 1 : 160 :: 2,04 Inches : 0,01275 of an Inch; which being added to the viſible Fall in the Tube gives the true Fall; that is, what it would viſibly have fallen, provided the Quickſilver in the Baſon had been ſo contrived, as to have kept at the ſame Height.

In like Manner was obtained the true Fall upon the Top of Diana's Peak } = 2,7976 Inches.
High Peak = 2,687

Now by Monſ. Bouguer's Account of the Fall of the Barometer we ſhall have, by multiplying the Inches Engliſh by 11,263, the Lines in an Inch, the Product will be Lines French, which being divided by 12, gives Inches and Lines. For 11,263 Lines = 12 Inches; and 1 Toiſe = 1,065416 Fathoms.

		Lines.	In.	Li.		Toiſes.	Yards Eng.
Now	2,053 × 11,263 =	23,02 =	1	11	Fall gives	276,0 =	588,1
	2,687 × 11,263 =	30,264 =	2	6¼		381,5 =	813,0
	2,796 × 11,263 =	31,503 =	2	7½		400,3 =	853,0

A Table of Meaſures of Length, French and Engliſh, that are equal one to another.

	French. Lines.		Engliſh. Inches.
	1	=	,088785 —
	2	=	,17757
	3	=	,266354
	4	=	,35514
	5	=	,4439
	6	=	,5327
	7	=	,6215
	8	=	,71028
	9	=	,79906
	10	=	,88785
	11	=	,97663
1 Inch =	12	=	1,065417 —

	French. Inches.		Engliſh. Inches.
	1	=	1,065416 +
	2	=	2,130833
	3	=	3,19625 .
	4	=	4,2616
	5	=	5,327083
	6	=	6,3925 ..
	12	=	12,785 ...
	24	=	25,57 .
	26	=	27,70083
	27	=	28,76625 .
	28	=	29,8316
	29	=	30,897085
	30	=	31,9625 .
½ Toiſe =	36	=	38,355 .

Aſtronomy is the Science which treats of the Motions, Magnitudes, Diſtances, Longitudes, Latitudes, Declinations, and Right Aſcenſions of the Heavenly Bodies, and of Appearances thence ariſing.

Of the Meaſure of Time.

ARTICLE I.

The Earth's Rotation about its Axis being uniform, makes the apparent Diurnal Revolution of the Stars about the Earth to be performed in equal Times; but the Sun being much brighter than the Stars is the Reaſon of its being choſen for the Meaſure of Time by its Diurnal Revolution; therefore an Aſtronomical Day is the Interval of Time elapſed between the Inſtant when the Center of the Sun is upon the Meridian and its Return thereto the next Day.

The apparent Motion of the Sun being unequal, therefore equal Time, which goes on always at the ſame Rate, cannot truly be meaſured by the Sun's Motion: Hence the Time which is obtained by the Sun, is called true or apparent Time; and the Time which flows uniformly, is called mean Time; according to which Time all the Celeſtial Motions are eſtimated and ſettled; and by which Time all Computations are made from Aſtronomical Tables: Wherefore Aſtronomers found it neceſſary, inſtead of thoſe apparent Solar Days, to ſubſtitute in their Place others that are equal, and a Mean between the longeſt and ſhorteſt, which is called the mean Solar Day; and from hence ariſes mean (Solar) Time.

ARTICLE II.

A Sidereal Day is that wherein, by a Rotation of the Earth on its Axis, any horary Circle returns to the ſame fixed Star; being equal to $23^h\ 56'\ 4,''09$ of mean Solar Time.

A Clock ſo regulated and adjuſted to the Right Aſcenſion of any Star, will ſhew the Right Aſcenſion of all the Stars; and thoſe Stars will always tranſit the Meridian at the ſame Time (exactly) excepting ſuch minute Difference of Time as may be occaſioned by the Aberration of Light and the Nutation of the Earth's Axis: Therefore 24^h Sidereal are $= 360°$ of the Equator or Longitude.

ADDENDA.

REMARK I.

THE hourly Motion to be uſed in order to find the mean Increaſe of the Moon's Longitude (from Noon or Midnight) to the Time of an Obſervation, in reſpect of the Meridian of London; and to which the variable Quantity of the Moon's Motion muſt be applied, as obtained per Tab. p. 30 to 33; which hourly Motions in the ſixth Column, p. 45, are adapted to the Middle of the Times ſpecified in the firſt and laſt Columns.

REMARK II.

The hourly Motions in the ſixth Column, p. 46 and 47, are adapted to their correſponding Times of Noon and Midnight in the firſt Column, and may be uſed when the Time of an Obſervation (reduced to the Meridian of London) does not differ more than an Hour from Noon or Midnight; but otherwiſe make uſe of the Difference in the third Column neareſt to the given Time.

REMARK III.

As to the Form of the Tables in p. 45, 46, and 47, the Intention being to ſhew a ready and accurate Method of obtaining the true Longitudes of the Sun and Moon, and other Requiſites, from the Paris Ephemeris, it being the only one publiſhed proper for thoſe Purpoſes: but as ſome of the Numbers in ſaid Ephemeris are not correct, therefore I adviſe thoſe Gentlemen who make uſe of it to take Notice, when the firſt Diff. of the Moon's Longitude do not increaſe or decreaſe in a regular Manner (as delivered in the third Col. p. 46 and 47) to take the Mid-day Diff. of Longitudes three Days before and three Days after the given Time of the Obſervation, and work as directed in p. 34, 35, and 36; and you will have the true Longitudes at Midnight, provided the Mid-day Longitudes were true. But if the Mid-day Diff. of Longitudes do not increaſe or decreaſe by an uniform and regular Acceleration or Retardation, then correct thoſe wherein you perceive the Error to lie by what you find would make them ſo, and then obtain the Midnight Longitudes, and in courſe the other Requiſites required.

In a larger Work, which I intend to publiſh this Summer, I propoſe placing the Columns containing the Requiſites for Longitude Obſervations in the following Manner, being more commodious and better for Practice.

A Table of the Moon's Longitude at mean Noon and Midnight, &c. &c.

1763 Feb.	☽'s Long. at mean Noon and Midnight.				Hourly Mo. Middle Ti.		Mean 2d Diff.		Latitude.			Daily Variat.		Mean 2d Diff.		Horizo. Parall.		Horizo. Diam.	
Days	s	°	′	″	′	″	′	″	°	′	″	′	″	′	″	′	″	′	″
20	1	24	27	27					2	33	23N.					55	57	30	30
					31	28,7 —	+ 5	25											
20½	2	0	45	11								55	3	— 7	25	56	21	30	44
					31	57,0	5	58											
21	2	7	8	35					3	28	26					56	45	30	57
					32	28,4	6	28											
21½	2	13	38	16								46	1	—10	43	57	12	31	12
					33	1,8 —	6	57											
22	2	20	14	37					4	14	27					57	39	31	26
					33	38,0 —	7	15											
22½	2	26	58	12								33	37	—14	8	58	8	31	42
					34	14,3 —	7	26											
23	3	3	49	3					4	48	4					58	37	31	59

Let it be required to find the Diff. of Long. of the Sun and Moon the 21ſt of February at 20 Min. paſt Seven at Night (mean Time, in reſpect of the Meridian of London) and the other Requiſites.

1763, 21 Feb.		s	°	′	″
☽'s Long. at Noon		2	7	8	35,
Hourly Mo. at 6 P. M.				32	28,4
					× 7⅓
Mean Incr. of Long.			3	57	48,8
Mean 2d Diff. 6′½ for 7ʰ⅓	—				46,0
True Increaſe	+		3	57	03,
☽'s true Long.		2	11	5	38
⊙'s ditto		11	2	58	27
Difference of Long.	=		98	7	11

		°	′	″
Latitude		3	28	26N
For 7ʰ⅓	+		15	8
☽'s true Lat.		3	43	34N.
Hor. Parall.			56	53
Hor. Diam.			31	01
⊙'s ditto			32	26,3
½ Diameters	=		31	43,6
Equa. of Ti. add to ⊙'s Ti. as in Remark 1. p. 53.	}			14,0
☽'s Hourly Mo.			32	32,4
⊙'s ditto			2	30,8
☽—⊙ per H.	=		30	01,6

In like Manner as in p. 19 and 21, I find the true hourly Motion, thus;

	′	h	″
By mean 2d Diff. of Long. 6½ for		7=	47,35
for		8=	43,35
Difference		1=	4,0
which add becauſe ☽ is increaſing.			
	′		″
Hence to	32		28,4
Add			4,0
☽'s Hourly Motion at 7½=	32		32,4

		s	°	′	″
☽'s true Long. at	6=	2	10	22	37
Ditto	7=	2	10	55	7
Ditto	8=	2	11	27	39
Ho. Mo. from 6 to 7	=			32	30
Ditto 7 to 8	=			32	32

REMARK IV.

If the Moon be W. of the Sun or Star, then ſubtract the Long. of the Moon from the Long. of the Sun or Star, and the Remainder will be the Difference of their Longitudes.

But if the Moon be E. of the Sun or Star, ſubtract the Long. of the Sun or Star from that of the Moon, and the Diff. of their Longitudes will remain.]

A New Method to find the Latitude at Sea with as much Certainty as by a Meridian Obſervation;

Provided Three Altitudes of the Sun can be taken at equal Intervals of Time, under the Circumſtances noted in the following Table.

Mer. Alt.	Intervals of Time, not leſs than	not greater than	The neareſt Obſer. to or from Noon not to exceed	
°	′	′	h	′
65	6	10		15
60	8	12		18
55	10	15		24
50	12	20		30
45	14	24		36
40	16	28		42
35	18	30		50
30	20	34	1	
25	20	36	1	
20	20	40	1	

Since the Meridian Alt. may always be known within the Limits of the firſt Column; therefore you will alſo know the proper Intervals of Time to be taken between the Obſervations, as noted in the 2d and 3d Columns. Likewiſe you may generally know, whether your neareſt Obſervation to the Meridian happens within the Limits of the 4th Col. which Particulars correſponding then obſerve.

Note, If the Ship does not alter her Courſe or Rate of ſailing conſiderably during the Time of the Obſ. make no Allowance for her Motion.

To find the Meridian Zenith Diſtance.

GENERAL RULE.

1ſt. Take the Z. Diſt. of the middle Obſervation from the greateſt Z. Diſt.

2d. Take the other Z. Diſt. from the greateſt Z. Diſt. which call the 2d Diff.

3d. From 4 Times the 1ſt Diff. take the 2d Diff. alſo from the Remainder take the 2d Diff. which call the 1ſt and 2d Remainders; then,

4th. Multiply the 1ſt Remainder by itſelf, and divide the Product by 4 Times the 2d Remainder, the Quotient will be the Number of Minutes to be ſubtracted from the greateſt Z. Diſt. obſerved; which gives the Meridian Z. Diſtance.

Art. 1. If the Quotient of the Diviſion ſhould happen to be equal to the 2d Diff. it would be a ſure Sign that the leaſt Z. Diſt. was taken at or near Noon, and therefore the true Z. Diſt.

Art. 2. If two of the Z. Diſt. ſhould happen to be equal, then the Inſtant of Noon was the middle Time between them; and when this happens the General Rule is reduced to the following

Art. 3. From one of thoſe equal Z. Diſtances take $\frac{1}{8}$ Part of its Difference from the other Z. Diſt. and you will have the true Z. Diſt. at Noon.

EXAMPLE I.

1761, per Watch,			☉'s tr. Z. D.	
	h	′	°	′
Sept. 16, at	11	0	=48	33
	11	20	=47	37
	11	40	=47	1
Subtract from			48°	33′
			—1	49
Merid. Z. Diſt. =			46	44 S
Decl.			2	29N
Lat. in			49	13N
Per Solar Tables Lat.			49	17N
Lat. by Meridian Alt.			49	14N

′

56×4=224

92 — 92

1ſt Rem. 132×132=17424

—92 ———— =109′=1° 49′

2d Rem. 40×4 = 160

EXAM. II.	The obſerved Z. Diſt. =	46°	32′
Per Art. 3.	Ditto	45	04
	Ditto	45	04
	Diff. =	1	28
	$\frac{1}{8}$ =	0	11
	Meridian Z. Diſt. =	44	53

To

ARTICLE III.

To reduce the Time of a Clock in any apparent Solar Rotation to mean Solar Time: Say, as the Seconds of Time in the Rotation by the Clock is to the Seconds of mean Solar Time in the apparent Solar Time, or to 360°, ſo is any Number of Seconds by the Clock to the Seconds of mean Solar Time, or to the Difference of Right Aſcenſion in Degrees.

ARTICLE IV.

To reduce Sidereal Time to mean Solar Time: Say, as 24^{h} is to $23^{h}\ 56'\ 4,''09$ ſo is any Number of Sidereal Seconds to mean Solar Seconds.

Alſo, as $24^{h} : 23^{h}\ 56'\ 4,''09 :: 360^{\circ} : 360^{\circ}\ 59'\ 8,''3 =$ the mean Solar Rotat.

Hence the mean Solar Day of 24^{h} is $= 59'\ 8,''3$ of Right Aſcenſion.

And the Difference between a mean Solar and Sidereal Day is $= 3'\ 55,''91$ of mean Solar Time, and $3'\ 56,''556$ of Sidereal Time, being the Acceleration of the Stars in a mean Solar Day.

ARTICLE V.

To reduce Sidereal Time to true Solar Time: Say, as 24^{h} is to $23^{h}\ 56'\ 4,''09$ + or — the daily Difference of the Equation of Time, ſo is any Number of Sidereal Seconds to the Seconds of true Solar or Apparent Time. Alſo,

As $23^{h}\ 56'\ 4,''09\ (=86164,''09) : 360^{\circ} :: 1^{h}\ (=3600'') : 15^{\circ}\ 2'\ 27,''9 = 15^{\circ},041$ Rotation in an Hour of mean Time.

And note in general, that the Return of Sun or Star to the Meridian conſtitutes a Day of 24 Hours, anſwering each to 360° reſpectively, called Solar or Sidereal Days, Hours, &c. and reducible to each other as above: hence, 15 Degrees are equal to one Hour in each.

Note, That the true Day, when the Sun is in Apogee, is $12''$ longer, and when in Perigee is $12''$ ſhorter, than the mean Solar Day.

To find the Variation by the Moon.

Make the Obſervations in all Reſpects as with the Sun; then reduce the Appt. Alt. to the True Alt. as before directed, p. 40, and find the True Decl. of the Moon to the Time at the Ship reduced to the Time at London, then compute as in the Sun's Obſervations, and the Reſult will be the Variation.

FINIS.

To find the Meridian Zenith Diſtance.

GENERAL RULE.

1ſt. Take the Z. Diſt. of the middle Obſervation from the greateſt Z. Diſt.

2d. Take the other Z. Diſt. from the greateſt Z. Diſt. which call the 2d Diff.

3d. From 4 Times the 1ſt Diff. take the 2d Diff. alſo from the Remainder take the 2d Diff. which call the 1ſt and 2d Remainders; then,

4th. Multiply the 1ſt Remainder by itſelf, and divide the Product by 4 Times the 2d Remainder, the Quotient will be the Number of Minutes to be ſubtracted from the greateſt Z. Diſt. obſerved; which gives the Meridian Z. Diſtance.

Art. 1. If the Quotient of the Diviſion ſhould happen to be equal to the 2d Diff. it would be a ſure Sign that the leaſt Z. Diſt. was taken at or near Noon, and therefore the true Z. Diſt.

Art. 2. If two of the Z. Diſt. ſhould happen to be equal, then the Inſtant of Noon was the middle Time between them; and when this happens the General Rule is reduced to the following

Art. 3. From one of thoſe equal Z. Diſtances take $\frac{1}{8}$ Part of its Difference from the other Z. Diſt. and you will have the true Z. Diſt. at Noon.

EXAMPLE I.

1761, per Watch,	h	′	☉'s tr. Z. D. °	′
Sept. 16, at	11	0 =	48	33
	11	20 =	47	37
	11	40 =	47	1
Subtract from			48°	33′
			—1	49
Merid. Z. Diſt. =			46	44 S
Decl.			2	29N
Lat. in			49	13N
Per Solar Tables Lat.			49	17N
Lat. by Meridian Alt.			49	14N

′

56×4=224

92 — 92

1ſt Rem. 132×132=17424

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2d Rem. 40×4 = 160

EXAM. II.	The obſerved Z. Diſt. =	46°	32′
Per Art. 3.	Ditto	45	04
	Ditto	45	04
	Diff. =	1	28
	$\frac{1}{8}$ =	0	11
	Meridian Z. Diſt. =	44	53

To

ARTICLE III.

To reduce the Time of a Clock in any apparent Solar Rotation to mean Solar Time: Say, as the Seconds of Time in the Rotation by the Clock is to the Seconds of mean Solar Time in the apparent Solar Time, or to 360°, ſo is any Number of Seconds by the Clock to the Seconds of mean Solar Time, or to the Difference of Right Aſcenſion in Degrees.

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To reduce Sidereal Time to mean Solar Time: Say, as 24^{h} is to $23^{h}\ 56'\ 4,''09$ ſo is any Number of Sidereal Seconds to mean Solar Seconds.

Alſo, as $24^{h} : 23^{h}\ 56'\ 4,''09 :: 360^{\circ} : 360^{\circ}\ 59'\ 8,''3 =$ the mean Solar Rotat.

Hence the mean Solar Day of 24^{h} is $= 59'\ 8,''3$ of Right Aſcenſion.

And the Difference between a mean Solar and Sidereal Day is $= 3'\ 55,''91$ of mean Solar Time, and $3'\ 56,''556$ of Sidereal Time, being the Acceleration of the Stars in a mean Solar Day.

ARTICLE V.

To reduce Sidereal Time to true Solar Time: Say, as 24^{h} is to $23^{h}\ 56'\ 4,''09$ + or — the daily Difference of the Equation of Time, ſo is any Number of Sidereal Seconds to the Seconds of true Solar or Apparent Time. Alſo,

As $23^{h}\ 56'\ 4,''09\ (=86164,''09) : 360^{\circ} :: 1^{h}\ (=3600'') : 15^{\circ}\ 2'\ 27,''9 = 15^{\circ},041$ Rotation in an Hour of mean Time.

And note in general, that the Return of Sun or Star to the Meridian conſtitutes a Day of 24 Hours, anſwering each to 360° reſpectively, called Solar or Sidereal Days, Hours, &c. and reducible to each other as above: hence, 15 Degrees are equal to one Hour in each.

Note, That the true Day, when the Sun is in Apogee, is 12″ longer, and when in Perigee is 12″ ſhorter, than the mean Solar Day.

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Make the Obſervations in all Reſpects as with the Sun; then reduce the Appt. Alt. to the True Alt. as before directed, p. 40, and find the True Decl. of the Moon to the Time at the Ship reduced to the Time at London, then compute as in the Sun's Obſervations, and the Reſult will be the Variation.

FINIS.

Abbreviations and Characters uſed in this Treatiſe.

An. Va.	Annual Variation.
Right Aſc.	Right Aſcenſion.
Aber.	Aberration.
Long. Lon.	Longitude.
Lat. Latit.	Latitude.
N. S. E. W.	North, South, Eaſt, Weſt.
co. ar.	Complement Arithmetical.
Appt. Alt.	Apparent Altitude.
s. co-ſ. t. co-t.	Sine, Co-ſine, Tangent, Co-tangent.
Ob. Obſer.	Obſervation.
Diſt. Decl.	Diſtance, Declination.
T. or Ti. red.	Time reduced.
⊙ ☽ *	Sun, Moon, Star.
tr. Diff.	True Difference.
Hor. Par.	Horizontal Parallax.
va. Qty.	Variable Quantity.
Incr. Decr.	Increaſe, Decreaſe.
Z. Diſt.	Zenith Diſtance.
Refr^{n}	Refraction.
∠ △ ∠s	Angle, Triangle, Angles.
s ° ′ ″	Signs, Degrees, Minutes, Seconds.
h ′ ″ ‴	Hours, Minutes, Seconds, Thirds.
m. Mo.	Mean Motion.
Azi.	Azimuth.
+ −	Plus or add, Minus or ſubtract.
× ÷	Times or multiplied, by or divided.
=	Equal to.
$\overline{☽ - ⊙} \times 2$	Moon's Lon.—Sun's multiplied by 2.

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ERRATA.

Page.	Line.	For	Read
2,	9,	thereto	to it.
21,	2,	Bor	For.
26,	12,	Appt. Center	Appt. Diſt. of their Centers.
42,	18,		of the ſame Name.
54,	2,	arives	arrives.
58,	6,	Sines	Signs.
59,	1, 3, 5, 6, 7, 15, 17,		
61,	15, 18, 20, 24, 25, 31,		
60,	23,	after 33° 16′	Refr^{n} allowed.

The other Errors, &c. that have occurred to my View, I have corrected with the Pen.

To ſuch Gentlemen as may conceive any Difficulties in properly underſtanding what this Treatiſe contains, I will undertake to make every Part of it extremely eaſy by Five or Six Days Inſtruction.

R. WADDINGTON.

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By the AUTHOR, and proper ASSISTANTS.

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